Abstracts Atmosphere/Ionosphere

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1. **Three years of space based atmosphere sounding with CHAMP: Results, highlights and future prospects**

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GPS radio occultation aboard CHAMP has been activated since February 11, 2001. With more than 260.000 occultation measurements as of June 2004 a unique long-term set of the innovative atmospheric remote sensing technique was created. The data are in use by more than 30 groups of scientist throughout the world. They brought significant progress for the GPS radio occultation technique and for their application to atmospheric research, weather forecast and climate research.

We review the results of three years radio occultation with CHAMP. The history and the current status of the experiment is characterized, results are presented, highlights are focussed on in more detail. Some of them are: operational data analysis without taking into account the Anti-Spoofing status of the GPS; feasibility of single-difference occultation processing; detection of ocean reflection signatures in the occultation signal, demonstration of near-real-time occultation processing and provision of analysis results to weather services.

Important applications of CHAMP data were and are: demonstration of a positive impact to global weather forecast by the UKMetOffice, investigations on tropopause climatology with high relevance for climate change studies, use for the calibration of other satellite sensor (e.g. MIPAS/ENVISAT) and for the preparation of processing systems for future occultation missions (e.g. COSMIC, EQUARS, METOP).

The overview is completed by a validation study using ~150.000 occultation measurements from CHAMP. The analysis results were generated using the recent version of GFZ analysis software 005. They are compared with data from ECMWF and the global radiosonde network. Excellent agreement is found in the upper troposphere and the stratosphere, with nearly bias-free measurements in relation to the independent meteorological data. The known refractivity bias was reduced by implementing the Full Spectrum Inversion (FSI) technique to the operational data analysis.

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2. **Radio Occultation Based Climatologies: Status of the CHAMPCLIM Project and First Results from the Summer Season 2003**

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CHAMPCLIM is a joint project of IGAM/University of Graz and GFZ Potsdam. It aims at exploiting the CHAMP RO data in the best possible manner for climate research. For this purpose, the complete CHAMP RO data provided by GFZ on excess phase level (GFZ level 2, ~180 profiles/day) are currently processed at IGAM to obtain atmospheric profiles of

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refractivity, geopotential height, and temperature. The IGAM retrieval scheme is focused on minimizing biases and yields a new atmospheric data set especially tuned for monitoring climate variability and change.
The atmospheric profiles (~150 profiles/day) are used to create climatologies on a monthly, seasonal, and annual basis by two different techniques: On the one hand by standard averaging-and-binning techniques, on the other hand, 3D-variational assimilation of the RO refractivity data into ECMWF analysis fields is performed, yielding global climate analyses on a more dense horizontal grid.
After optimizing the RO data processing for climate applications and validation of the retrieval results using various reference data sources (still on-going), the main emphasis is now on operational issues, processing of the 2002-2003 data, and on the creation of climatologies including error estimates. Our presentation will give an overview over the status of the CHAMPCLIM project, and show validation results and first climatologies from the summer season (JJA) 2003.

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3. **Connections of the parameters of gravity waves with amplitude and phase variations of the CHAMP radio occultation signal**

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Internal gravity waves (IGW) play a main role in the dynamical state and temperature regime of the atmosphere. The wind speed fluctuations and variations of the density, pressure, temperature of the neutral gas in the atmosphere and electron density distribution in the mesosphere and ionosphere can be caused by the IGW influence. The radio occultation (RO) experiments appear to be a new tool for studying the variations caused by IGW on a global scale. The RO amplitude variations are more sensitive to the wave structures in the atmosphere and ionosphere than the phase of the RO signal because they give directly important information on the vertical gradients of the refractivity in the atmosphere and ionosphere. The current theory can be applied to connect the amplitude variations in the RO signal with IGW characteristics. For this aim it is necessary to apply the IGW dispersion and polarization relationships to find the relevant IGW parameters from the amplitude variations of the RO signal. As follows from preliminary analysis, the RO amplitude variations can be connected with vertical distribution of the phase and spatial frequency of IGW. The RO phase variations can be used to establish the basic state of the atmosphere in the RO region including the vertical distribution of the refractivity, temperature and Brunt-Vaisala frequency. Than the vertical distribution of the horizontal wind perturbations and intrinsic phase speed of IGW can be obtained from the RO amplitude variations. This theoretical scheme has been applied to the practical analysis of the CHAMP and GPS/MET RO data. Using our method we found the vertical profiles of the horizontal wind perturbations and their vertical gradient associated with the IGW influence. For two RO events we compared the estimated values of the horizontal wind perturbations with aero- logical data and found fairly good agreement. We conclude that the amplitude and phase of the GPS occultation signals contain important information about the IGW propagation in the atmosphere on a

global scale.

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4. **Correction technique for Radio Occultation data with the use of regional meteorological models**

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In the present work an approach is proposed for correction of reconstructions obtained in radio occultation (RO) experiments with CHAMP satellite.
The presence of gradient structures in the atmosphere is well known to be the main source of errors when applying the RO techniques. Therefore the proposed approach makes use of a priori estimation of possible errors of signals reconstruction during numerical "end-to-end" experiment employing regional atmosphere model. Reconstruction errors in the numerical experiment are assumed "behaviorally similar" to real errors.
Correction technique was verified for the data from Arctic region with the use of regional atmospheric model HIRHAM4 (AWI, Potsdam) in 2001-2003. Profiles measured by radiosondes (RS profiles, current UKMO data) were taken as reference height profiles of meteorological parameters and refraction index, and CHAMP data (GFZ archive, Potsdam) hit in immediate proximity of meteorological post (closer than 50 km).
The proposed approach allows us to estimate statistically the possible errors of the data reconstruction in HIRHAM4 model for a specified region where the profile is reconstructed, and to use these for correcting CHAMP data with respect to RS profiles, the latter being assumed the most accurate.
Results are shown for the correction based on the proposed approach for altitudes 3-12 km. The preliminary data obtained prove the proposed procedure to be effective in more than 70% cases - the mean value and rms of the error in the profile for the given height range decrease, that is, on the whole, the corrected CHAMP profile becomes closer to RS profile.
The study shows that even in the presence of systematic error in the model, correction of real profiles is still possible if the model contains adequate information about the gradients of meteorological structures. Accuracy of the correction procedure based on such principles depends not only on the adequacy of the meteorological model to real situations but also on additional conditions such as the state of ionosphere and magnetosphere.

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5. **Excess-Doppler prediction technique for the open-loop signal tracking of the Lagrange Radio Occultation GPS receiver: performance validation through comparisons with Champ observations**

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One of the main problems affecting the GPS radio occultation signal tracking is the premature phase lock loss, due in particular to anomalous propagations phenomena (i.e., multipath, defocusing, tropospheric scintillations, etc.) often occurring inside the deeper layers of the atmosphere. This may cause the lack of the first samples (those near the Earth's

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surface) in the retrieved refraction index profiles.
From a receiver point of view, a possible remedy is the open loop tracking, in particular when signals are supposed to emerge from the troposphere. This strategy, that will be implemented in the ASI - LAGRANGE GPS Radio Occultation receiver (ROSA) developed by Laben S.p.A., will properly work only if a good Excess-Doppler evolution prediction can be pre-computed in advance by the receiver.
The prediction strategy adopted is a modification and an optimization of the technique suggested by S. V. Sokolovskiy [*Radio Sci., 36, 2001*]. This work provides the results of the validation carried on through comparisons with the about 200 Excess-Doppler observations collected by the CHAMP Radio Occultation GPS receiver during the winter 2002/2003 above Europe. The results suggest an allocation of at least 30 Hz bandwidth around the predicted Excess-Doppler value, in order to make the receiver to correctly center the frequency of GPS signal when it works in open loop conditions.

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6. **An analysis of the negative refractivity bias detected in GPS radio occultation data: Results from simulation studies, aerological soundings and CHAMP observations**

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An analysis of 108,058 atmospheric refractivity profiles observed by CHAMP during 2002 and 2003 reveals a negative bias compared to ECMWF meteorological fields at altitudes below 5 km. The bias is most pronounced in the tropical Pacific, Central Africa, Indonesia, and India with values reaching -4%. In order to separate bias contributions caused by critical refraction from contributions induced by the receiver tracking process a comprehensive end-to-end simulation study was performed using radio sonde profiles obtained regularly by Alfred Wegener Institute aboard research vessel POLARSTERN since 1982. Within a subset of 2917 profiles recorded between 60N and 60S on the Atlantic ocean between 29 December 1982 and 14 November 2003, 40.2% (1172 profiles) indicate the presence of critical refraction with vertical refractivity gradients below -157 km^-1. Layers exceeding the critical refractivity value are mainly located between 1 to 2 km altitude, above 3 km the occurrence of critical refraction can be disregarded. Simulations including a receiver signal tracking model and using these 2917 sonde observations confirm that four quadrant carrier phase extraction outperforms the arctangent method currently implemented on CHAMP. Within regions of low signal-to-noise ratio an interesting alternative to 'fly-wheeling' and open-loop tracking methods is carrier loop band width reduction. Changing the band width from 30 to 10 Hz improves data yield at 0.5 km altitude by about 16%.

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7. **Atmospheric densities derived from CHAMP/STAR: An overview**

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The CHAMP mission profile is particularly interesting for upper atmosphere studies, since it provides a nearly complete latitudinal coverage, while complete solar local time sampling is achieved every four months approximately. Total atmospheric densities have been derived

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from the STAR data from May 2001 through November 2003. These densities can be used to study the following, non-exhaustive, list of topics:

1. characterise and quantify thermospheric variability;
2. evaluation of proxy-indicators for solar activity, F10.7 (radio flux) and the chromospheric Mg II index;
3. thermospheric wave activity related to solar storm events;
4. travelling atmospheric disturbances;
5. thermosphere model error analysis and improvement.

An overview of results obtained over the last 3 years for these 5 topics is given, focusing in particular on points 3 and 5 during the huge solar storm of October 2003. The effects of this unique event on the upper atmosphere, as seen by CHAMP, are shown. Finally, a first comparison of CHAMP and GRACE-derived densities is presented.

P 1 **Cross-Validation of MIPAS/ENVISAT and GPS-RO/CHAMP Temperatures**

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MIPAS/ENVISAT and GPS-RO/CHAMP measure temperature and water vapour profiles in the troposphere and temperature in the stratosphere. This analysis presents comparisons of the stratospheric temperatures retrieved from MIPAS limb mid-infrared emission measurement using the IMK data processor and from GPS radio occultation observations using GFZ retrieval routines. The data used for comparison are taken from the global observations of 14 days in September/October 2002 and 20 days in October/November 2003. Both individual profiles and zonal means of the temperatures between 8 and 30 km show very good agreement. The global mean differences averaged over the height region of 8 and 30 km are 0.05 and 0.2 K for the periods of 2002 and 2003, respectively. There is a weak tendency for MIPAS temperatures to be slightly lower than GPS-RO/CHAMP in the altitudes below 25 km, but higher above. The hot bias increases with increasing height and reaches a maximum of ~1.5 K at 30 km. Comparisons with corresponding radiosonde data at this altitude show a cold bias of ~1K for CHAMP and a hot bias of ~1K for MIPAS. We investigate the effect of possible bias in the initialization of the GPS occultation data with ECMWF at 43 km to the observed bias at 30 km.

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P 2 **Inversion of Radio Occultations with Noise**

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Recently radio occultation data with atmospheric multipath behaviour have attracted much attention. It has been shown that methods based on Fourier integral operators (CT, FSI, CT2) can effectively unfold multipath behavior. Furthermore, this approach gives a high accuracy for the retrieved bending angle profiles. However, it is not clear to what extent this is affected by the noise on radio occultation amplitude and phase data.
In the present work, we investigate the effect of noise on the inversion of radio occultations. We introduce various filtering methods and investigate how this affects the resolution. For comparison, we also study the case where the inversion is based on the phase data without using the amplitude. It is still possible to unfold the multipath behavior without using amplitude data but it results in reduced accuracy for the bending angle profiles. However, by applying a model for the amplitude (or using a strongly smoothed version of the measured, noisy amplitude) the results are improved. Our investigations are based on both simulated radio occultation data with multipath behavior and CHAMP occultation data.

P 3 **Monitoring of CHAMP data with the 3dvar system of DWD**

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The Deutscher Wetterdienst (DWD) is planning to migrate the assimilation system of its global weather forecast model to a three-dimensional variational analysis (3DVAR). The new 3DVAR of DWD includes a forward operator (ray-tracing) for the computation of bending angle from model fields and its adjoint, i.e. bending angles from occultation observations can be directly assimilated into the model. In order to prepare for their future usage, data from CHAMP satellite have been received and monitored at DWD since January 2004. The observed profiles of bending angles are derived from the path delays processed by the GeoForschungsZentrum (GFZ) using the Canonical Transformation (CT) method. In order to monitor the retrieved profiles also at low heights, there is no cut-off border of low-quality data but complete profiles with error estimate are produced. Every profile is compared with that simulated by the 3-hour forecast of the global model. Results from monthly statistics show a satisfactory quality of the CHAMP data in the upper troposphere, especially if the error estimate information is used to remove outliers (these are mainly due to the poor quality of the L1 signal amplitude). In the lower troposphere, and mostly in the tropics, the well known problem of multipath results in large disagreement between observations and background. This disagreement can be partially reduced if only those observations, which error estimate is below a certain threshold, are selected. Assimilation tests to tune the value of these thresholds and to investigate the impact of the CHAMP are planned for the near future.

P 4 **Error levels in atmospheric surface pressure analysis fields**

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Surface atmospheric pressure fields are related to the mass of the atmosphere, and they also drive nonisostatic changes in the ocean mass distribution. Both effects imply gravitational signals potentially measured by GRACE. We are investigating the quality of surface pressure fields produced by two major weather centers (U.S. National Centers for Environmental Prediction and the European Centre for Medium-Range Weather Forecasts). We do so by comparing observations of surface pressure from weather stations on the Earth's surface with analysis values interpolated to the observation location. Over the oceans such surface values are measured at ship, buoy, and island-based stations. The surface pressure fields of the two meteorological centers currently have comparable error levels, though they were considerably different 10 years ago, particularly over the southern oceans. For a recent year, between March 2002 and Feb. 2003, for example, error levels of the two centers were estimated regionally. The largest standard deviations, around 6 hPa, occur in some sectors of the high latitude oceans; other regions in these latitude bands have considerably smaller errors, and in lower latitudes errors are typically <2 hPa. In preliminary analysis over land, the mean error standard deviation approaches 6 hPa in areas of highest topography.

P 5 **Validation of CHAMP and SAC-C Occultation Profiles**

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CHAMP and SAC-C provide a unique opportunity for their inter-comparison. Hajj et al. (2002) did a point-to-point comparison of CHAMP and SAC-C. In this paper, we propose a new indirect method to do the statistical comparison—zonal mean method. First, we compare the difference between each satellite's occultation with model (ECMWF or NCEP) profiles interpolated to the occultation locations. The difference and statistics map of CHAMP and SAC-C comparing with ECMWF/NCEP are computed in zonal band within a certain time period, respectively; then subtract the difference of CHAMP-NCEP map and SAC-C-NCEP map, obtaining the difference of CHAMP-SAC-C. The benefit of this method is eliminating the step of finding matching occultation events and could potentially include all the measurements in the analysis. We expect to see how consistent the occultation measurement is. The long term stability and error pattern distribution are also very interested for us and vital for the future application of occultation to climate study. From which, the concept of free of calibration could possibly be validated. Meanwhile, the zonal error distribution, the relative performance in planetary boundary layer of each satellite will also be analyzed in the paper.

P 6 **Derivation of Vertical Water Vapor Profiles from GPS Radio Occultation with CHAMP**

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GPS radio occultation measurements on board Low Earth Orbiting (LEO) satellites such as CHAMP (Challenging Minisatellite Payload) provide a new calibration free data source for vertical profiling of atmospheric parameters like temperature and water vapor on global scale.

Considering current and planned LEO missions (e.g. COSMIC, EQUARS or METOP), these measurements will provide a valuable data base for climatological investigations and weather prediction in the future.
The GPS radio occultation experiment within the CHAMP satellite mission has been activated now for more than 3 years. More than 270,000 occultation measurements are expected as of July 2004. Since the life time of the CHAMP satellite is predicted to last longer than 2007, the first and unique long-term set of GPS occultation data is anticipated. GFZ provides results of an operational occultation data analysis via the Information System and Data Center (ISDC). The results are available at different processing levels: atmospheric excess phase data, bending angles and vertical profiles of refractivity.
The temperature profiles provided at ISDC are calculated under dry air assumption. The resulting dry temperature profiles are almost identical with the real temperature at altitudes above 10 km, where the wet component of the refractivity can be neglected. However, vertical profiles of the tropospheric temperature and water vapor can only be derived using ancillary atmospheric information from e.g. meteorological analyses (either temperature or water vapor).
Tropospheric water vapor and temperature profiles are derived using the improved version (005) of GFZ's operational refractivity profiles, which is provided via ISDC since March 2004. Here the Full Spectrum Inversion (FSI) technique is used for data analysis in the lower troposphere, resulting in a significant reduction of the negative refractivity bias in this region. To combine CHAMP refractivity measurements with ancillary meteorological information in a statistically optimal way an operational 1Dvar retrieval code is used for the water vapor retrieval. Even if a unique separation of dry and wet component of refractivity is not possible, especially the initial humidity assumption may be improved provided that refractivity measurement and ancillary temperature are of sufficient quality. We validate the results with radiosonde data and ECMWF analyses. Potentials for global water vapor monitoring are demonstrated.

P 7 **GPS Radio Occultation with CHAMP: An Application for Climate Research**

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The temperature structure in the tropical upper troposphere and lower stratosphere (UTLS) region is discussed based on Global Positioning System (GPS) radio occultation (RO) data from the German CHAMP (CHAllenging Minisatellite Payload) satellite mission. Dynamical, chemical, and radiative coupling between the stratosphere and troposphere are among the many important processes that must be understood for prediction of global change. The exchange of mass, water, and trace gases between the troposphere and stratosphere takes place across the tropopause that is characterized by an abrupt change in the temperature lapse rate. Thus, the continuous identification and monitoring of the tropopause on a global scale is an important goal in atmospheric and climate research. This can be performed by the radio occultation technique due to its high vertical resolution, long-term stability, weather independent capability and global coverage. Based on three years of CHAMP RO data the structure and temporal and spatial variability of the tropical tropopause are discussed. This includes an overview of the global tropopause characteristics, the discussion of the annual cycle and the latitudinal-longitudinal structure of the tropical tropopause. In the CHAMP RO temperature data clear evidence of the stratospheric quasi-biennial oscillation (QBO) was found.

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8. **Ionospheric sounding by means of GPS measurements onboard CHAMP**

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The GPS radio occultation measurements of the ionosphere have been performed onboard CHAMP since 11 April 2001. More than 115000 vertical electron density profiles have been derived so far by a model assisted retrieval technique. The talk reviews the main results obtained by analyzing the ionospheric radio occultation (IRO) measurements including validation and modeling.
The talk addresses also the use of the GPS navigation measurements onboard CHAMP. These 0.1 Hz sampled data may effectively be used to reconstruct the three-dimensional electron density distribution of the topside ionosphere and plasmasphere.
Thus, significant structures can be analyzed in the vicinity of the CHAMP orbit plane averaged over the revolution period of 93 minutes.
Presented also are perturbation events derived from both ground and CHAMP based GPS measurements. From this aspect, a more comprehensive view on the ionospheric perturbation mechanisms is achieved.

9. **Similarity of the amplitude variations in CHAMP radio occultation signal and Earth-based observations of the radio waves scintillations**

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Two types of the amplitude scintillations have been observed early on satellite-to-Earth links in the radio signals emitted by geo-stationary satellites at gigaherz band frequencies: noisy variations with broad temporal spectrum (C-type) and isolated, impulsive, fluctuations (S-type). Similar patterns have been revealed, also, in the CHAMP radio occultation (RO) amplitude scintillations. In addition, the quasi-periodical and diffractive patterns have been observed frequently in the CHAMP RO signals. The cause of occurrence of type C, as shown in some publications, is closely connected with the spread F at nighttime and sporadic E in daytime. The S-type, quasi-periodical and diffractive scintillations can be associated with influence of the inclined plasma's layers with sharp gradients in the electron density distribution in the F and sporadic E layers of the ionosphere. These scintillations can be analyzed using an analytic model, which accounts for the horizontal gradients in the

ionosphere. This model explained origin of the amplitude scintillations as a consequence of influence of sharp gradients in the plasma distribution, which are perpendicular to the ray path of the radio waves. The analytic model allowed measuring the electron density and its gradient using the form of the amplitude variations and their rate. This approach may be important for progress in solutions of the direct and inverse problem of the radio wave propagation in the ionosphere. The analytic model can be used in combination with an inversion algorithm to restore the distribution of the electron density and its gradient inside the ionospheric disturbances using temporal amplitude variations of the radio signals on the communication links satellite-to-satellite and satellite-to-Earth.

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10. **Medium- and Small-Scale Ionospheric Irregularities Detected by CHAMP Radiooccultation Measurements**

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Travelling ionospheric disturbances (TIDs) and other types of ionospheric inhomogeneities of characteristic wavelength 30-500 km are studied on the basis of CHAMP radiooccultation experiment data. The latitudinal distribution and the diurnal and seasonal dynamics of the irregularities are given. The most prominent of them is strongly disturbed winter ionosphere in polar regions. The results are compared with a number of other TID data sources, including incoherent scatter radars. Possible explanations of the obtained results are discussed, including the geomagnetic activity and the atmospheric gravity waves (AGW) generated in the neutral atmosphere. An attempt was made to find a connection between AGW in the lower layers of atmosphere and ionospheric wave-like structures observed by CHAMP.

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11. **Search for Earthquake signatures in the ionosphere by ground and space based GPS measurements**

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The ionospheric response to earthquakes has been reported in the literature since many years. Since energetic coupling from the lithosphere via the atmosphere to the thermosphere/ionosphere is realized by acoustic waves, ionospheric radio occultation (IRO) measurements onboard CHAMP were analyzed to search for a correlation. As it will be shown, the IRO measurements detect numerous wavelike or irregular phenomena in the ionosphere. Although wave like phenomena were observed in the spatial and temporal vicinity of earthquakes, no evidence could be found that they were really associated to earthquakes. The results of case and statistical studies are discussed.
In a parallel study, using the dense GPS network in North America, relative TEC data derived from differential phases were analyzed to detect signatures in correlation to selected earthquakes of magnitude > 6. Earthquake related structures were found after the Denali earthquake on 3/11/2002 and during the California earthquake on 22/12/ 2003. It is assumed that these significant structures are associated to acoustic waves excited in the atmosphere by seismic waves. Detection techniques and wave propagation features will be discussed.

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12. **Global Thermosphere Density Response During the Solar Storms of 2002 and 2003 from CHAMP Accelerometer Measurements**

R. S. Nerem, J. M. Forbes, E. K. Sutton, and S. Bruinsma

Measurements of atmospheric density from the CHAMP satellite near 410 km are used to illustrate the dependence of seasonal, latitudinal, and day/night response of the thermospheric region to elevated levels of geomagnetic activity. The latitude vs. time evolutions of total mass density at specific local times are determined from accelerometer measurements collected by the CHAMP satellite. These results are compared with density predictions from the NRLMSISE-00 empirical density model. Zonal winds near the equator along with polar north/south winds are analyzed using cross-track accelerometer measurements from CHAMP. The time periods considered include a significant geomagnetic storms during 2002 and 2003, which exhibit elevated magnetic activity of approximately Kp ~ 5-8. Response during these storms are compared to typical quiet-time behavior (Kp ~ 1-2). This time interval provides an opportunity to examine the equatorward penetration of storm-induced disturbances under conditions where the mean solar-driven summer-to-winter circulation, and the circulations driven by high-latitude heating, reinforce and oppose each other in opposite hemispheres. We find a number of orbits to be characterized by 100-1000 km-scale structures, suggesting the presence of aurorally-generated waves. Day/night differences in the equatorward penetration of both global-scale and small-scale density perturbations are also examined in terms of diurnal variations in the solar-driven meridional flow.

13. **High-Latitude Thermospheric Neutral Density Variations Observed by the STAR Accelerometer on CHAMP**

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GeoForschungsZentrum Potsdam, Germany

The CHAMP satellite, with its sensitive STAR accelerometer onboard, provides the opportunity to investigate thermospheric dynamics in great detail. On its near-polar, low-Earth orbit (about 400 km), it is well suited to map the air density and winds at high latitudes. In this study we concentrate on the auroral, polar cap, and cusp regions. Great care is used in cross-calibration of the along-track and cross-track axes of the accelerometer using the periodic signature of the corrotation winds perpendicular to the orbit as a diagnostic. This also allows after calibration the removal of the effect of cross-track winds from the raw accelerations and enables us to produce more refined density values. Subtracting predicted densities given by the MSIS90 model from the observations allows the study of variations away from the average background in order to shed light on small-scale features such as high latitude winds and density increases. These are assumed to be due to upwelling from heating sources caused by ionospheric currents in the auroral and cusp regions.

14. **IMF By-related Cusp currents on different scales**

P. Stauning and J. Watermann

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With data from Oersted and CHAMP in their drifting orbits it has been possible to investigate the important high-latitude field-aligned current (FAC) and ionospheric current systems

located in the noon sector at cusp latitudes in much greater details than possible at earlier missions like the Magsat (1979-80). With the abundance of high-quality data the comprehensive statistical basis has now enabled the development of sophisticated models for the current distribution and intensities in dependence of seasonal, solar wind and magnetospheric parameters. However, there are still large uncertainties involved in using the new models primarily due to the lack of precise knowledge of the temporal and spatial development of the currents in relation to the highly variable solar wind parameters. Furthermore, the high-precision magnetic measurements made at high temporal resolution corresponding to spatial resolutions down to less than 100 m have demonstrated the occurrences of highly structured magnetic variations in the low-altitude Cusp region. The observed magnetic perturbations indicate structures of very intense but thin sheets or narrow filaments of mixed up- and downward currents up to several hundreds of $\mu A/m^2$ embedded in large-scale FAC structures of only up to a few $\mu A/m^2$. The intensities and locations of fine-scale FAC structures are closely related to solar wind conditions. The presentation will focus on the properties of the IMF By-related cusp currents on different temporal and spatial scales.

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15. **Evidence for night-time signal in observatory data related to solar wind sector structure and investigation of coupling mechanism**

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British Geological Survey

An analysis of Ørsted satellite and observatory hourly mean values in 2001 previously revealed a periodic signal in the Y residuals of a global spherical harmonic model, which correlated well with the Y component of the Interplanetary Magnetic Field in 2001. In this study we investigate the occurrence of this signal using only observatory data, for 1995 onward. We also investigate the value of the Tsyganenko model (in comparison with Ørsted data from 2001 and 2003) in helping us determine to what extent the signal is simply a result of penetrating IMF or whether it is a result of some other current system.

P 8 **1D Spherical Elementary Current Systems and Their Use for Determining Ionospheric Currents from Satellite Measurements**

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The method of 1D spherical elementary current systems is a new way for determining ionospheric and field-aligned currents in spherical geometry from magnetic field measurements by low-orbit satellites. It is based on 1D spherical elementary current systems (1D SECS), which are derived by placing infinitely many 2D SECSs of identical amplitude at a constant latitude. The resulting two types of 1D SECSs are independent of longitude, and by superposition can reproduce any ionospheric and field-aligned current system with the same property. One type of 1D SECSs is divergence-free and toroidal with a poloidal magnetic field, and the other type is curl-free and poloidal. Associated with the divergence of the curl-free type are radial field-aligned currents. The magnetic field of the combined curl-free 1D SECS and field-aligned currents is toroidal and restricted to the region above the ionosphere. Ionospheric currents are determined by placing several 1D SECSs at different latitudes and choosing their amplitudes in such a way, that their combined magnetic field as

closely as possible fits the measured one. The 1D SECS method has been tested using both modeled and real data from CHAMP, and found to work excellently in 1D cases.

P 9 **Solar Zenith Angle Control of Field-aligned Currents: A Statistical Study of the Southern Hemisphere**

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The statistical features of the field-aligned currents (FACs) in the southern polar ionosphere are investigated using CHAMP vector magnetic field data. The period considered comprises two years providing a double coverage of the seasons and about a six-fold coverage of all local times. Special attention is paid to the influence of the solar illumination induced conductivity on the morphology features of FACs on normal conditions when merging electric field is not exceeding 2mV/m. It shows that the solar influence on the conductivity strongly controls the FAC densities at the dayside. A linear relation between merging electric field and the peak FAC density exists, which implies that the dayside FAC densities are directly controlled by the conductivity caused by solar radiation. Solar elevation does not affect the nightside FAC density, because of the energy of the particles carrying the FAC. On the dayside a systematic difference of the footprint latitude between sun-lit and dark conditions emerges, which is a displacement following the varying illumination conditions of the auroral region in the noon sector over a day. Our results clearly show that the sources of FACs on the dayside behave like a voltage source and on the nightside like a current source.

P 10 **Evidence for connection between the amplitude variations in the CHAMP radio occultation signal and DST index**

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With appearing of the radio navigational satellites (GPS/GLONASS) the favorable conditions arisen for global observation of the natural processes in the ionosphere and mesosphere. CHAMP radio occultation (RO) experiments allow obtaining on a global scale the spatial distribution of the ionospheric perturbations. It is found that the histograms of the root mean square (rms) of the amplitude variations of the CHAMP RO signals in the height interval 40-100 km are containing important information on the integral behavior of the ionospheric activity. The maps of the ionospheric perturbations with rms of the amplitude variations grater than 5%, found from the CHAMP RO measurements (about of 6000 events per month), revealed their seasonal and diurnal variations depending on the solar activity. For example, these maps indicated the displacement of the areas with strong ionospheric events during May-December 2001 from subtropical regions to polar areas. These maps also revealed concentration of the ionospheric activity near the north and south geomagnetic poles

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and in some equatorial regions. The maps relevant to Septembers 2001, 2002, 2003 demonstrated gradual diminishing of the general quantity of strong ionospheric perturbations by 5-10 times in accordance with the weakening of the solar activity. Additional analysis of the CHAMP RO signals during magnetic storms September 25-26, 2001, and October 29 – 31, 2003, discovered the dependence of the rms histograms on the DST index of the interplanetary magnetic field. As follows from this analysis a possibility exists for introducing the RO amplitude index, which connects the ionospheric activity with the DST index.

P 11 **The latitudinal relation between small-scale magnetic field variations and energetic particle precipitation in the low-altitude cusp**

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We have studied more than 50 cases of low-altitude cusp detection during the February 16-22, 2002, SIRCUS campaign period. About half of them were inferred from DMSP F-13/14/15 particle spectrometer observations and the other half from small-scale magnetic field measurements made onboard the Ørsted and CHAMP satellites. The locations of the satellites during the detection of these signatures were converted into AACGM coordinates, and the geomagnetic latitude of these signatures set in relation to the statistical, IMF-Bz dependent particle cusp latitude derived by Newell et al. (1989). The DMSP inferred particle cusp latitude matches the statistically expected latitude while the small-scale magnetic field regime appears to cover not only the cusp but also the poleward section of the low-latitude boundary layer (LLBL). We suggest that the perturbations resulting in small-scale magnetic field variations are generated in the LLBL-cusp transition zone, possibly associated with the process of newly opening geomagnetic field lines and merging with the interplanetary field.

P 12 **Webbased Geographical Information Services**

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WebGIS holds the potential to make distributed geographic information (DGI) available to a worldwide audience. Internet users will be able to access GIS applications from their browsers without purchasing proprietary GIS software.
Two different technologies will be used for implementing services of the CHAMP-/GRACE ISDC that visualize geospatial data on the internet:

- the UMN mapserver for dynamic and interactive visualisation of the CHAMP-occultation data and the display of locations of GPS-groundstations and solarstations
- SVG for animated Integrated Water Vapor Profiles of the Global Atmosphere Sounding Project (GASP).

Furthermore technologies of creating maps based on cost-free geodata will be discussed.

P 13 **Ionosphere/Plasmasphere Imaging based on GPS TEC Data from CHAMP and SAC-C**

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Ground based GPS measurements are well proved in terms of monitoring the vertical Total Electron Content (TEC) of the ionosphere. The GPS receivers installed on board of LEO (Low Earth Orbiting) satellites such as CHAMP and SAC-C provide a unique data source for ionospheric remote sensing on global scale.
Both satellites CHAMP and SAC-C track permanently several GPS satellites using zenith looking antennas dedicated for precise orbit determination. These 0.1 Hz sampled dual frequency navigation measurements provide valuable information on the ionization state of the upper ionosphere and plasmasphere up to GPS altitude on global scale.
After preprocessing and calibration, link related TEC measurements are derived from the GPS navigation observations. Three dimensional electron density distribution is reconstructed by assimilating these TEC data into the Parameterized Ionospheric Model (PIM). We present reconstruction results for selected assimilation examples. The assimilation technique will be described briefly. We discuss validation results using electron density measurements from the Langmuir Probe on board CHAMP and compare reconstructions based on TEC data from only one and from both satellites.