U42B-04 1645h INVITED

Geomagnetic Variations and Their Possible Effects on System Earth

Karl-Heinz Glassmeier[1,2] (+49 531 391 5214; kh.glassmeier@tu-bs.de)

[1]Institute for Geophysics, Technical University of Braunschweig, Mendelssohnstrasse 3, Braunschweig 38106, Germany

[2]MPI for Aeronomy, Max-Planck-Strasse 2, Katlenburg-Lindau 37191, Germany

The Earth magnetic field exhibits a variety of temporal variations with time scales ranging from a few seconds up to millions of years. The most pronounced variation is certainly a polarity transition during which the geomagnetic field strength decays down to about 10-20 % of its current value. A question of immediate interest is whether and in which way System Earth reacts on such a dramatic event. First the magnetosphere changes its size and shape. Due to the decreasing geomagnetic field the magnetopause is located much closer to the surface of the Earth. If the field exhibits strong quadrupole components magnetic reconnection can happen in the northern dayside magnetosphere with the southern hemisphere featuring a closed magnetosphere. Also the magnetotail structure changes drastically. Energetic particle entry occurs not only in dipolar cap regions but over much enlarged areas. As the ionospheric conductivity depends on the geomagnetic field strength first estimates furthermore indicate that externally driven geomagnetic variations are stronger during times of a polarity transition. The weaker field also makes the middle atmosphere much more sensitive to energetic particle events and large natural ozone holes are very likely during polarity transitions as first model calculations indicate.

U42B-05 1700h INVITED

A Model Study of the Impact of Magnetic Field Reversal on Atmospheric Composition During Solar Proton Events

Charles H Jackman[2] (301-614-6053; Charles.H.Jackman@nasa.gov); Miriam Sinnhuber[1] (49-421-2184352; miriam@iup.physik.uni-bremen.de); John P Burrows[1] (49-421-2184548; burrows@iup.physik.uni-bremen.de); Martyn P Chipperfield[3] (44-113-233-6459; martyn@env.leeds.ac.uk); May-Britt Kallenrode[4] (mkallenr@uni-osnabrueck.de); Klaus F Kunzi[1] (49-421-218-3909; kunzi@physik.uni-bremen.de); Manual Quack[1,4] (quack@iup.physik.uni-bremen.de)

[1]University of Bremen, Institute of Environmental Physics University of Bremen, Bremen D-28334, Germany

[2]NASA Goddard Space Flight Center, Code 916 NASA Goddard Space Flight Center, Greenbelt, MD 20771, United States

[3]University of Leeds, School of the Environment University of Leeds, Leeds LS2 9JT, United Kingdom

[4]University of Osnabruck, University of Osnabruck, Osnabruck D-49069, Germany

During a polarity transition of the Earth's magnetic field, the structure and strength of the field change significantly from their present values. This will alter the global pattern of charged particle precipitation into the atmosphere. Thus, particle precipitation is possible into regions that are at the moment effectively shielded by the Earth's magnetic field. A two-dimensional global coupled chemistry, radiation, and transport model of the atmosphere has been used to investigate how the increased particle precipitation affects the chemical composition of the middle and lower atmosphere. Ozone losses resulting from large energetic particle events are found to increase significantly, with resultant losses similar to those observed in the Antarctic ozone hole of the 1990s. This results in significant increases in surface UV-B radiation as well as changes in stratospheric temperature and circulation over a period of several months after large particle events.

U42B-06 1715h

Do Lunar Soils Tell us When the Geomagnetic Field First Appeared?

Minoru Ozima[1] (EZZ03651@nifty.ne.jp)

Yayoi N Miura[2] (yayoi@eri.u-tokyo.ac.jp)

Frank A Podosek[3] (fap@levee.wustl.edu)

Kanako Seki[4] (seki@stelab.nagoya-u.ac.jp)

[1]Department of Earth Planetary Sciences, University of Tokyo, Bunkyo-Ku, Tokyo 113-0033, Japan

[2]Earthquake Research Institute, University of Tokyo, Bunkyou-Ku, Tokyo 113-0032, Japan

[3]Department of Earth Planetary Sciences, Washington University, One Brookings Drive, St. louis, MO 63130, United States

[4]Solar-Terrestrial Environmental Lab., Nagoya University, Honohara, Toyokawa 442-8507, Japan

When did the Earth's geomagnetic field first appear? Paleomagnetic studies trace the geomagnetic field back only to about 3.5 Ga ago [1]. It has been taken for granted that the development of the geomagnetic field was concomitant with the formation of the Earth's core, but the time of core formation is not well known, nor is the role of the inner core in the generation of the geodynamo, so this fundamental issue remains enigmatic. We show that the isotopic compositions of N implanted in ancient lunar soils may reflect admixture of solar wind and terrestrial atmospheric component, suggesting transport of atmospheric components to the Moon. The geomagnetic field would prevent any effective ion loss from the atmosphere [2], but if the geomagnetic field was absent in the early Earth the escape of ions from the ionosphere would be enhanced considerably, and a substantial amount of terrestrial atmospheric ions may have been transported to lunar soils. Therefore, we propose that close examination of N isotopic compositions in ancient lunar soils may provide clues concerning the time of the appearance of the geomagnetic field. The PVO (Pioneer Venus Orbiter) observations have suggested the loss of 1E6 - 1E8 O+ cm-2s-1 from the Venus atmosphere [3]. This substantial ion loss is understood to reflect direct interaction between the solar wind and the upper atmosphere in the absence of a permanent dipole field. For N+/O+ of about 0.02 around the ionopause [4], we would expect N+ loss of about 2E5 cm-2s-1. Venus's atmosphere may serve as a proxy for the primitive atmosphere in the early Earth, which was likely to consist predominantly of CO2/CO [5]. We thus expect that a similar amount of N+ would escape from the Earth in the absence of the geomagnetic field. Also considering that the Earth was much closer to the Moon in the first several hundred Ma [6], we infer from simple geometrical considerations that a few percent of escaping ions from the Earth's ionosphere may have directly hit the lunar surface. Isotopic inventory considerations suggest that the implantation of about 1E4cm-2s-1 of N of terrestrial origin would suffice to explain the hypothesized non-solar N in ancient lunar soils. This amount of non-solar N could be attributed to terrestrial N that was transported to the Moon if the Earth did not have a geomagnetic field. It is known that the dynamical coupling between the Earth and the Moon is so stable that the near side of the Moon has remained facing the Earth for nearly the whole history of the Earth-Moon system [7]. Therefore, we predict that a considerable amount of terrestrial N would be observable in near side lunar soils whose exposure times predate the commencement of the geomagnetic field, whereas soils from the far side should not show terrestrial components. We propose that comparison of N isotopic components in ancient lunar soils from the far side with those from the near side could help resolve the time of the appearance of the geomagnetic field. [1] Hale C.J. Nature, 399, 249, 1987. [2] Seki et al., Science, 291, 1847, 2001. [3] Kasprzak et al. JGR, 11, 175, 1991. [4] Grebowsky et al. JGR, 9055, 1993. [5] Abe Y., Lithos, 30, 223, 1993. [6] Abe M. et al., Proc. 30th Int. Geological Conf., 26, 1, 1997. [7] Murray C.D. and Dermott, S.F., Solar System Dynamics, Cambridge Univ. Press,1999.

U42B-07 1730h INVITED

Solar Activity and Climate - in Light of the Decay of the Dipole

Eigil Friis-Christensen (+45 3532 5707; efc@dsri.dk)

Danish Space Research Institute, Juliane Maries Vej 30, Copenhagen DK-2100, Denmark

The geological history shows that climate has always been changing. The climate is the result of very complex interactions between various atmospheric processes, which are not well understood. Variations in solar activity seem to have a significant - but not simple - effect on climate. Recently it has been suggested that solar activity modulation of cosmic rays influences the formation and properties of clouds and thereby the radiation balance of the Earth. This topic was selected as one of six 'Areas to Watch in 2003' in the 20th December 2002 edition of Science. Since the Earth's magnetic field also has a modulating effect on the cosmic ray flux into the atmosphere, one might expect an effect on climate as well. A review of solar activity variations and climate changes will be given with emphasis on those aspects that may be affected by the varying geomagnetic field.

U51A MCC: 3001-3003 Friday 0800h

Human-Induced Climate Variations Linked to Urbanization: From Observations to Modeling I

Presiding: **J Shepherd,** NASA Goddard Space Flight Center**; M Jin,** University of Maryland, College Park

U51A-01 0800h INVITED

Promise and Capability of NASA's Earth Observing System to Monitor Human-Induced Climate Variations

Michael D King ((301) 614-5636; michael.d.king@nasa.gov)

Goddard Space Flight Center, Code 900, Greenbelt, MD 20771, United States

The Earth Observing System (EOS) is a space-based observing system comprised of a series of satellite sensors by which scientists can monitor the Earth, a Data and Information System (EOSDIS) enabling researchers worldwide to access the satellite data, and an interdisciplinary science research program to interpret the satellite data. The Moderate Resolution Imaging Spectroradiometer (MODIS), developed as part of the Earth Observing System (EOS) and launched on Terra in December 1999 and Aqua in May 2002, is designed to meet the scientific needs for satellite remote sensing of clouds, aerosols, water vapor, and land and ocean surface properties. This sensor and multi-platform observing system is especially well suited to observing detailed interdisciplinary components of the Earth's surface and atmosphere in and around urban environments, including aerosol optical properties, cloud optical and microphysical properties of both liquid water and ice clouds, land surface reflectance, fire occurrence, and many other properties that influence the urban environment and are influenced by them. In this presentation I will summarize the current capabilities of MODIS and other EOS sensors currently in orbit to study human-induced climate variations.

U51A-02 0830h INVITED

Urban Aerosol-Induced Changes of Precipitation

Daniel Rosenfeld[1] (+972-2-6585821; daniel@vms.huji.ac.il)

Amir Givati[1] (+972-2-6586514; givati@vms.huji.ac.il)

Alexander Khain[1] (+972-2-6585822; khain@vms.huji.ac.il)

Guy Kelman[1] (+972-2-6585823; superk@pob.huji.ac.il)

[1]Institute of Earth Sceinces, The Hebrew University of jerusalem, Jerusalem 91904, Israel

Precipitation has been shown often to be enhanced over and downwind of major urban areas. These effects were most noticeable in convective clouds of the warm season, and were ascribed to dynamic causes, such as the urban heat island and the urban topography. In contrast, recent observations have shown that urban and industrial aerosols suppress rain and snow, by providing large concentrations of small cloud condensation nuclei (CCN), which when ingested into the clouds create large number of small cloud droplets. The clouds need to grow to greater depth and colder cloud top temperatures for the onset of precipitation. Therefore it was expected that precipitation would be most suppressed when the pollution is ingested into relatively shallow and short-living clouds. Such clouds occur in winter over orographic barriers downwind of coastal cities. This was examined by measuring the orographic enhancement factor (RO, ratio of rainfall over the hills versus the upwind lowland rainfall) of the precipitation downwind of the urban areas in California and Israel. It was found that in both locations RO has decreased by 15 to 25 percent during the last century whereas no change occured in side wind little urbanized areas. Some compensation occurred further downwind on the drier downwind side of the mountains. The aerosols suppress the onset of precipitation also in warm-base convective clouds that develop in moist tropical air masses, such as occur during the summer in Houston and St. Louis. Simulations of clouds with explicit microphysical processes show that the delay of the onset of the warm rain in such clouds delays also the onset of the downdraft, and by that allows the updraft to invigorate further and produce more violent and precipitation producing thunderstorms. This is proposed as an additional enhancement mechanism that works at the same direction of the urban heat island. The conversion from warm to ice precipitation processes advects

more cloud water to the supercooled levels higher in the cloud. The added cloud water and updrafts are the two ingredients that electrify clouds, thereby providing also for more intense and frequent thunderstorms. Such enhancement in thunderstorm activity over and downwind of Houston has been observed, and awaits in situ observations for confirmation of the proposed mechanism, in the form of the proposed HEAT project. In summary, air pollution aerosols can have large impacts on the precipitation and dynamics of the clouds for both suppression and enhancement of precipitation. The pollution tends to suppress precipitation from relatively shallow and short living clouds. In contrast, the delay of precipitation in deep convective clouds that form in tropical air mass can invigorate them and the dynamical feedback can result in overall enhanced precipitation amount.

U51A-03 0900h

Effects of urbanization and global warming on subsurface temperature in the three mega cities in Japan

Makoto Taniguchi[1] (81-75-229-6193; makoto@chikyu.ac.jp)

Yasuo Sakura[2] (81-43-290-2847; ysakura@earth.s.chiba-u.ac.jp)

Takeshi Uemura[3] (81-742-27-9202; a028506@student.nara-edu.ac.jp)

[1]Research Institute for Humanity and Nature, 335 Takashima-cho, Kamigyo-ku, Kyoto, KYO 602-0878, Japan

[2]Department of Earth Sciences, Chiba University, 1-33, Yayoi, Inage, Chiba, CHI 263-8522, Japan

[3]Department of Earth Sciences, Nara University of Education, Takabatake, Nara, NAR 630-8528, Japan

Effects of surface warming due to urbanizations on subsurface thermal regime were found in many cities over the world. Although the effect of global warming is estimated to be 0.5 degree centigrade during the last 100 years, the effects of urbanization on subsurface environment are not evaluated yet. The purpose of this study is to evaluate the effects of surface warming due to urbanization on subsurface temperature in three mega cities, Tokyo, Osaka and Nagoya, Japan. Analyses of subsurface thermal transport have been made using different scenarios with the time of start warming and the ratio of surface warming. Comparisons between observed subsurface temperature and calculated one have been made. According to the comparisons, the effect of urbanization on subsurface environment should be considered since 100, 80 and 60 years ago in Tokyo, Osaka, and Nagoya, respectively. The ratios of surface warming due to urbanization and global warming were estimated to be 2.5, 2.0 and 1.5 degree centigrade in Tokyo, Osaka and Nagoya, respectively.

U51A-04 0915h

Observation and Analysis of the Urban Heat Island in Singapore

Winston T.L. Chow[1] ((65)6874 3831; g0202394@nus.edu.sg)

Matthias Roth[1] ((65)6874 6103; geomr@nus.edu.sg)

[1]Department of Geography, Faculty of Arts and Social Sciences, National University of Singapore., 1 Arts Link, Singapore 117570, Singapore

Until recently, research into the Urban Heat Island (UHI) phenomenon has been primarily focused in cities in temperate climates. In contrast, there has been hitherto relatively little interest in examining UHIs in tropical cities. With the majority of tropical cities undergoing rapid urbanization, knowledge of this aspect of the urban climate modification is essential to mitigate potential climate-related problems in the urban environment. This paper will present preliminary results of an ongoing project based on fixed and mobile observations from 2002 to 2004. This project is one of the first comprehensive studies of temperature and humidity distributions of a tropical city. The focus is on the spatial distribution and temporal dynamics of the temperature and humidity fields of Singapore. Climate parameters are measured in different landuse types (commercial, CBD, industrial, high-rise and low-rise residential areas) and compared with observations taken at a rural area of predominantly secondary rainforest. This data is analyzed over diurnal and seasonal periods and compared with results from temperate and other tropical UHI studies. Preliminary results indicate that there are significant differences in the magnitude and timing of the peak UHI in Singapore compared with work done in mid-latitude cities. There also appears to be a link between the role of moisture and UHI intensity: Drier periods are generally associated with larger UHI intensity differences. The role of different urban canyon geometries in affecting temperature cooling rates is also demonstrated. Lastly, suggestions and measures that can be undertaken to lower UHI stresses on the urban population will be reviewed.

U51A-05 0930h

Assessing Urbanization Impact on Long-term Rainfall Trends in Houston

Parastou Hooshialsadat[1] (phooshi@uark.edu)

Steven J. Burian[2] ((801) 585-5721; burian@eng.utah.edu)

J. Marshall Shepherd[3] ((301) 614-6327; shepherd@agnes.gsfc.nasa.gov)

[1]University of Arkansas, 4190 Bell Engineering Center, Fayetteville, AR 72701, United States

[2]University of Utah, 122 South Central Campus Drive, Suite 104, Salt Lake City, UT 84112, United States

[3]NASA Goddard Space Flight Center, Code 912.0, Greenbelt, MD 20771, United States

Rainfall data from 50 rain gauges within and nearby Houston were analyzed to identify annual and warm season (June, July and August) rainfall trends from 1950 to 2000. Comparison of the mean annual and warm season rainfall amounts in the urban area to those in an upwind control region and a downwind urban impacted region indicates that the urban area has experienced higher average annual and warm season rainfall amounts during the 50-year time period than the upwind control region. The urban-impacted region has also experienced higher rainfall amounts, while the urban area and urban-impacted region do not have a statistically significant difference in rainfall amounts. Trend analyses were also performed on the 50-yr time series of annual and warm season rainfall amounts by calculating a statistic representing the differences in annual and warm season rainfall amount for each year between the urban area and upwind control region, the urban impacted region and the upwind control region, and the urban area and urban impacted region. The trend of the difference statistic versus time and population was assessed using straight-line plots and regression analyses. The regression results suggested that there is an increasing trend for the urban area-upwind control region difference with both time and population growth, but no significant trend for the urban-impacted region-upwind control region and urban area-urban-impacted region difference statistics.

U51A-06 0945h

Monitoing PM2.5 from Space

D. Allen Chu[1] (301-614-6237; achu@climate.gsfc.nasa.gov); Lorraine Remer[2] (301-614-6194; remer@climate.gsfc.nasa.gov); Jim Szykman[3] (757-864-2709; james.j.szykman@nasa.gov); Yoram Kaumfan[3] (301-614-6189; kaufman@climate.gsfc.nasa.gov); Doreen Neil[4] (757-864-8171; d.o.neil@express.larc.nasa.gov); Brad Pierce[4] (757-864-8172; Robert.B.Pierce@nasa.gov)

[1]NASA GSFC code 913/SSAI, NASA Goddard Space Flight Center, Greenbelt, MD 20771, United States

[2]NASA GSFC code 913, NASA Goddard Space Flight Center, Greenbelt, MD 20771, United States

[3]Office of Air Quality Planning and Standards, US EPA, Hampton, VA 23681, United States

[4]NASA LaRC, NASA Langley Research Center, Hampton, VA 23681, United States

MODIS sensors onboard the EOS Terra and Aqua satellites launched in 1999 and 2002 provide the revolutionized perspectives to study the Earth systems. MODIS ability to derive the first aerosol product over land has advanced our understanding of aerosols into the source regions. The analysis of MODIS-derived columnar aerosol loading has shown good correlation (correlation coefficient 0.8-0.9) with EPA PM2.5 (particulate matter with particle size less than 2.5 mm) at surface in metropolitan areas (e.g., New York City, Chicago, Houston, etc.) and also over broad regions including 11 states and Washington DC. At present, the EPA, along with Regional Planning Organizations, and state and local governments use a multitude of decision support tools to assess, control, and report the nature of air pollution related to PM. However, the current existing air quality decision processes solely rely on urban scale model and ground-based network. Using MODIS aerosol data can aid significantly in tracking the movement of pollutants, which can be used as a proxy of PM2.5 for regions without ground measurements. NASA (GSFC and LaRC) is collaborating with EPA and NOAA in providing MODIS aerosol data to benchmark PM2.5 forecast in the East US in the summer 2003. This activity is to prototype similar activities in the following years using MODIS direct broadcasting to study transport (national, international, or intercontinental) issues and assess performance effectiveness of existing air quality regulations. Improvements of MODIS aerosol algorithm are planned to achieve better spatial resolution for urban pollution and health-related studies.

U51B MCC: Level 1 Friday 0830h

The Core-Mantle Boundary: Theoretical, Experimental, and Observational Constraints III Posters

Presiding: **A D Brandon,** NASA Johnson Space Center

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U51B-0001 0830h POSTER

Non Linear Analysis of Differential Travel Times of PKP Phases and D" Structure

Raphael Garcia[1] ((+33) 145114152; garcia@ipgp.jussieu.fr)

Hrvoje Tkalcic[2] (tkalcic1@llnl.gov)

Sebastien Chevrot[3] (chevrot@pontos.cst.cnes.fr)

[1]IPGP DGSP UMR7096 CNRS, 4, Ave de Neptune, Saint Maur 94107, France

[2]Lawrence Livermore National Laboratory, P.O. Box 808, L-206, Livermore CA 94551, United States

[3]LDTP UMR5562 CNRS, Observatoire Midi-Pyrénées 14, Ave E. Belin, Toulouse 31400, France

The triplication of PKP core phases has been widely used to extract information on the structure of both the inner core and the base of the mantle. We present a new method that performs a non linear inversion of the 3 main core phases waveforms (PKP(DF), PKP(BC) and PKP(AB)). The differential travel times between these body waves are measured with high accuracy even when they interfere on the records, or when pPKP depth phases are present. This property allows us to investigate the epicentral distance range 146-149 degrees previously hidden by the interference between the 3 core phases, and new ray paths associated to shallow events. Preliminary results reveal strong variations of the differential travel times residuals involving the PKP(AB) phase, that could be related to short wavelength heterogeneities at the base of the mantle. These observations are presented for particularly well resolved regions of the base of the mantle and interpreted in terms of geodynamic processes at the Core-Mantle boundary.

U51B-0002 0830h POSTER

Anisotropy of S wave velocity in the lowermost mantle using broad-band data recorded at Syowa in Antarctica

Yusuke Usui[1] (81-76-264-5747; yusuke@hakusan.s.kanazawa-u.ac.jp)

Yoshihiro Hiramatsu[1] (81-76-264-5734; yoshizo@hakusan.s.kanazawa-u.ac.jp)

Muneyoshi Furumoto[1] (81-76-264-5733; furumoto@hakusan.skanazawa-u.ac.jp)

Masaki Kanao[2] (81-3-3962-3275; kanao@nipr.ac.jp)

[1]Graduate School of Natural Science and Technology, Kanazawa University, Kakuma, Kanazawa 920-1192, Japan

[2]National Institute of Polar Resaerch, 1-9-10 kaga, Itabashi-ku, Tokyo 173-8515, Japan

We investigate the velocity structure of the lowermost mantle (D") beneath the Antarctic Ocean. We analyze seismograms from 16 deep earthquakes in south Pacific subduction zones from 1990 to 2001 recorded by STS-1 broad-band seismographs at Syowa station in Antarctica. The source-receiver combinations span distances range 85°-95° with associated S waves passing through D" beneath the Antarctic ocean. Differential travel times of split S waves are estimated to be up to 2s, showing that longitudinal components (SV) energy arrives earlier than transverse components (SH) energy. The absence of significant splitting for S waves with turning points more than four hundred kilometers above the core-mantle boundary (CMB) indicates that anisotropy is localized within the D" region.

Differential travel times among S, ScS and SKS phases and waveform modeling are used to construct the velocity structure in D". We calculate synthetic waveforms by the *Direct Solution Method* (DSM: Geller and Ohminato, 1994; Geller and Takeuchi, 1995). SH shows a double arrival at the epicentral distance near 89°. However SV in this range remains a single arrival. Isotropic model an not explain these observation. We find that synthetics for transverse isotropic models with SH velocity discontinuity (SYYM model) explain well the observed differential travel times and waveforms. The thickness of the anisotropic zone, where SH