[4]NASA Goddard Space Flight Center, Code 695, Greenbelt, MD 20771, United States

The Geoeffective Halo Coronal Mass Ejection (CME) that departed from the Sun on 28 October 2003 also encountered the planet Mars. The Mars Global Surveyor (MGS) magnetometer/electron reflectometer (MAG/ER) instrument package detected the passage of the CME through elevated electron fluxes and an increase in the magnetic field magnitude in the magnetic pileup region over typical values. Unlike terrestrial space weather, global magnetic storms are not expected to occur at Mars because Mars does not have a significant global dipole magnetic field. However, interaction with the small-scale magnetic structures tied to the Martian crust does occur. We investigate space weather effects on the electron environment and magnetic field morphology as seen from the 400 km mapping altitude of MGS during the late October solar storms.

SA23B-05 1435h

Solar Energetic Particles Measured by the Mars Global Surveyor

Gregory Delory[1] (gdelory@ssl.berkeley.edu); Janet Luhmann[1] (jgluhman@cism.ssl.berkeley.edu); David Mitchell[1] (mitchell@ssl.berkeley.edu); Camron Gorguinpour[1] (camron@ssoar.org); David Brain[1] (brain@ssl.berkeley.edu); Christina Lee[1] (clee@ssl.berkeley.edu)

[1]Space Sciences Laboratory, MS 7450 University of California, Berkeley, CA 94720, United States

We discuss the use of the MGS MAG/ER instrument in the characterization of coronal mass ejections (CMEs) and solar energetic particles (SEPs) at Mars. The Electron Reflectometer (ER) onboard Mars Global Surveyor (MGS) is an imaging electrostatic analyzer designed to measure the energy/angle distributions of 10 eV to 20 keV electrons. During quiet conditions, the ER has a background count rate, integrated over the entire anode, of about 7 counts/sec (c/s). This background is caused by high energy particles that penetrate the 2-mm-thick instrument casing and impact the detector. Since these particles bypass the electrostatic analyzer section, they produce a count rate that is independent of the instrument's energy sweep, typically dominating the signal in the highest 2-3 energy channels. During CME and SEP events, these background count rates increase by several orders of magnitude or more. Using these penetrating particle counts, we show several examples of classical SEP and CME shock arrival profiles at Mars obtained during the MGS mapping orbit, including events from the recent October-November storms in 2003. In many cases the ER data interpretation is supported by magnetic field enhancements, including some examples of the direct measurement of the shock. We also discuss the time variability of these events in orbit around Mars, comparisons to simultaneous measurements by the MARIE instrument and at Earth by the ACE spacecraft, the implications of these results for CME velocity models, and the resulting radiation environment at the surface of Mars.

SA23B-06 1450h

Atmospheric Chemistry on Mars Using the Global Mars Multiscale Model (G3M)

John C McConnell[1] (416 736 2100 x77709; jcmcc@yorku.ca); Youssef Moudden[1] (youssef@nimbus.yorku.ca); Antonio Garcia Munoz[1] (garcia@nimbus.yorku.ca); Jacek Kaminski[1] (jacek@yorku.ca); Irina Verkhovsky[1] (irinav@yorku.ca); Miguel Lopez-Valverde[2] (valverde@iaa.es); Manuel Lopez-Puertas[2] (puertas@iaa.es); Ayodeji Akingunola[1] (deji@nimbus.yorku.ca); Victor Fomichev[1] (victor@nimbus.yorku.ca)

[1]Department of Earth and Space science and Engineering, 4700 Keele Street, Toronto, ON M3J1P3, Canada

[2]Instituto de Astrofisica de Andalucia (CSIC), Apdo 3004, Granada 18080, Spain

The chemical stability of the atmosphere of Mars appears to be determined by HOx chemistry which in turn is related to the distributions of water and ozone. Using the G3M (Global Mars Multiscale Model) as a host we have added chemistry and dust modules. The dynamical model is based on a SL/SI dynamical framework employed in the Canadian Meteorological Service of Canada's weather forecast model, GEM (Global Environmental Multiscale) model. The model includes comprehensive physics and has been extended to over 150 km and been run in global uniform (at 1.3^o horizontal resolution) and zoom mode with an interior resolution of 10 km). The version that we will present has a top at 150 km with uniform horizontal resolution. The chemistry added includes photolysis of CO_2 and water vapour and related products and also includes ozone chemistry. Long-lived chemical species are subject to transport by the resolved circulation and by diffusion within the PBL. At present we have not included heterogeneous chemistry. We will present seasonal distributions of CO and ozone and compare with available observations.

SA24A CC: 519 A Tuesday 1530h

Mars Space Weather and Upper Atmosphere Science II *(joint with A, P, SH, SM)*

Presiding: **K Retherford,** Southwest Research Institute**; W Ward,** University of New Brunswick

SA24A-01 1530h INVITED

SPICAM on Mars Express: Vertical profiles of Density, Temperature , Ozone and Dust From Stellar Occultations in the Martian Atmosphere

Eric Quemerais[1] (int+33 1 64 47 43 17; eric.quemerais@aerov.jussieu.fr); Jean-Loup Bertaux[1] (bertaux@aerov.jussieu.fr); Oleg Korablev[2] (korablev@aerov.jussieu.fr); Francois Forget[4] (forget@lmd.jussieu.fr); Severine Perrier[1] (severine.perrier@aerov.jussieu.fr); Didier Fussen[3] (fussen@bira.be); Charles Cot[1] (cot@aerov.jussieu.fr); Joana Tamminen[5] (tamminen@fmi.fi)

[1]Service d'Aeronomie, BP3 route des gatines, Verrieres le Buisson 91371, France

[2]Space Research Institute, 84/32 Profsoyuznaya, Moscow 117810, Russian Federation

[3]Belgian Institute for Space Aeronomy, 3 avenue Circulaire, Brussels B-1180, Belgium

[4]4Laboratoire de Météorologie Dynamique, University Paris 6, 4 Place Jussieu,BP 102, Paris 75000, France

[5]5Finnish Meteorological Institute, PO Box 503, Helsinki FIN-00101, Finland

SPICAM, a light-weight (4.8 kg) UV-IR dual spectrometer on board Mars Express orbiter, is dedicated primarily to the study of the atmosphere and ionosphere of Mars. The UV imaging spectrometer (118 - 320 nm, resolution 1 nm, intensified CCD) is dedicated to nadir viewing, limb viewing and atmospheric vertical profiling by stellar and solar occultation. We report about the first ever stellar occultations around Mars, and the first measurements of the UV absorption of CO2 in the upper atmosphere of Mars. By orienting Mars Express to a star, the UV spectral transmission of the atmosphere is measured with SPICAM as a function of altitude and wavelength, by comparing the star spectra seen above the atmosphere and through the atmosphere. The main absorbers are CO2 (below 200 nm) and dust (above 200 nm), with some ozone at particular latitudes and seasons. Because of the huge variation of the UV absorption cross-section of CO2, it provides a large dynamic range of slant density measurements. After vertical inversion, the atmospheric pressure and temperature are retrieved from 150 km down to 15-25 km, where dust is usually preventing further measurements. Several occultations have been obtained, and their results will be compared to the LMD General Circulation Model predictions. Collection of future vertical profiles of density and temperature will help in the refinement of meteorological and dynamical Mars atmospheric models. This is essential for future missions that will rely on aerocapture and aerobraking.

SA24A-02 1550h

New Observations of UV Airglow in the Upper Atmosphere of Mars with SPICAM on Mars Express.

Francois Leblanc[1] (leblanc@aerov.jussieu.fr); Jean-Loup Bertaux[1]; Oleg Korablev[2]; Eric Quemerais[1]; Olivier Witasse[4]; Paul C. Simon[3]; Jean Lilenstein[5]

[1]Service d'Aeronomie du CNRS/IPSL, BP3, Verrieres-le-Buisson 91371, France

[2]Space Research Institute (IKI), 84/32 Profsoyuznaya, Moscow 117810, Russian Federation

[3]Belgian Institute for Space Aeronomy, 3 avenue Circulaire, Brussels B-1180, Belgium

[4]ESA-ESTEC, Kepler Laan, Noordwijk soso, Netherlands

[5]Laboratoire de Planetologie de Grenoble, Grenoble, Grenoble 38, France

On board Mars Express orbiter, the UV channel of SPICAM is dedicated primarily to the study of the atmosphere and ionosphere of Mars. This UV imaging spectrometer (118 - 320 nm, resolution 1 nm, intensified CCD) is dedicated to nadir viewing, limb viewing and atmospheric vertical profiling by stellar and solar occultation. We report here about the first SPICAM measurements of the Mars UV airglow obtained during limb observations. They were obtained by orienting Mars Express to a predefined inertial pointing direction, and the drift of the spacecraft along its orbit allowed to obtain a vertical profile of the limb emissions. On the day side, above the dust scattering layer, which extends up to 40-50 km, the UV day glow spectrum contains the emissions of CO (Cameron bands produced by dissociation of CO2), the O I line at 297.2 nm, and the (0,0) transition of CO2+at 289 nm. Other emissions are also present. Thanks to observations of calibrated stars, intensity lines are retrieved with an excellent photometric accuracy. Comparisons of absolute intensities and altitude distributions will be compared to model predictions. Future observations of seasonal variations with SPICAM should allow us to much better constrain the mechanisms leading to loss to space through the understanding of the mechanisms driving the formation of this region.

SA24A-03 1605h

An Analysis of the Martian Far-Ultraviolet Dayglow Observed by the Far-Ultraviolet Spectrographic Explorer (FUSE)

Randy Gladstone[1] (210-522-3581; rgladstone@swri.edu)

Kurt Retherford[1] (210-522-3809; kretherford@swri.edu)

Alan Stern[1] (303-546-0262; astern@swri.edu)

Richard Link[2] (703-967-7156; richard.link@cox.net)

Stephen Bougher[3] (734-647-3585; bougher@umich.edu)

[1]Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78238-5166, United States

[2]Algoma Research, Inc., P.O. Box 7423, Fairfax Station, VA 22039-7423, United States

[3]University of Michigan, 2455 Hayward Avenue, Ann Arbor, MI 48109-2143, United States

The Far Ultraviolet Spectroscopic Explorer (FUSE) satellite was used to observe Mars on 7/8/2001 for 8031s and on 8/10/2001 for 13241s. During these observations, 6233s and 10988s, respectively, occurred when the satellite was within Earth's shadow and terrestrial airglow contamination was minimized. An earlier observation by *Krasnopolsky and Feldman* (Icarus, *160*, 86–94, 2002) lasted 18340s, of which about half was obtained from within Earth's shadow. The FUSE spectra cover the wavelength range 90-120 nm, at a resolving power of about 5000, and contain a large number of dayglow emission lines of H, He, C, N, O, Ar, N^+, C^+, and Ar^+, as well as bands of N_2 and CO, as described by *Krasnopolsky and Feldman*. Here we present detailed full-disk simulations of several of atomic emission line multiplets, using recent 1-D and 3-D model atmospheres, to place constraints on disk-averaged abundances of the major species of the upper atmosphere.

SA24A-04 1620h INVITED

Model Studies of the Structure of the Martian Ionosphere for Various Solar Fluxes in both the EUV and Soft Xray Regions.

Jane L Fox (937 775 2983; jane.fox@wright.edu)

Department of Physics, Wright State University, 3640 Colonel Glenn Hwy, Dayton, OH 45435, United States

A two-peaked structure of the Martian ionosphere has been seen in the Mars Global Surveyor Radio Science electron density profiles. Sometimes the lower peak is seen only as a shoulder and sometimes as a distinct peak. The lower peak is produced by absorption of soft xrays, and the upper peak by absorption of the main part of the EUV solar fluxes. We present the results of models of the Martian thermosphere/ionosphere in which we employ different solar EUV and soft xray fluxes. We have found that a distinct lower peak cannot be reproduced by scaling the solar fluxes below 250 Å by a constant factor of 3–6. This is in contrast to models of the terrestrial low altitude ionosphere, where such a scaling has been found to reproduce the electron density profiles measured by incoherent scatter data (Solomon et al., 2001). We have

modeled the ionosphere for solar fluxes from Hinteregger, and the S2K fluxes from K. Tobiska. We find that there is a large difference in the model ionospheres that result from the S2K v1.24 fluxes, which are based on the SNOE soft xray data, and the v2.22 fluxes, which are based on the TIMED SEE data. These differences are not limited to the soft xrays, but extend into the EUV as well. Previous models based on the SERF2 solar fluxes (Tobiska, 1991) had shown the double peaked structure (Fox et al., 1995). We show that the appearance of the double peak depends on both the EUV and soft xray fluxes.

SA24A-05 1640h

Testing Simple Parameterizations for the Basic Characteristics of the Martian Ionosphere

Paul Withers[1] (+1 617 353 1531; withers@bu.edu)

Michael Mendillo[1] (+1 617 353 1531)

[1]Boston University, Center for Space Physics 725 Commonwealth Avenue, Boston, MA 02215, United States

Approximately 2000 profiles of ionospheric electron density between 100 and 200 km altitude have been generated by the Radio Science Experiment on Mars Global Surveyor and publicly released on the PDS. Basic parameters that can be extracted from each electron density profile include the altitude, peak density, and thickness of two distinct ionospheric layers, the topside scale height, and the overall total electron content and equivalent slab thickness. With the 2000 profiles spanning the years 1998-2001, the analysis will include effects of variability in the longitudes, latitudes, local times, and seasons sampled. Simple scaling laws for the behaviour of these ionospheric parameters will be tested. We will investigate the hypothesis that layer width, slab thickness, and topside scale height can be related to neutral atmospheric temperatures and that, when combined with peak altitudes, these results can be related to neutral atmospheric pressures. We will discuss the implications of our results for interactions between the neutral and ionized portions of the martian upper atmosphere.

SA24A-06 1655h

Ionospheric Layers of Mars and Earth

Henry Rishbeth[1] (011-44-2380-592099; hr@phys.soton.ac.uk)

Michael Mendillo[2] (617-353-2629; mendillo@bu.edu)

[1]School of Physics and Astronomy, University of Southampton, Southampton SO17 1BJ, United Kingdom

[2]Center for Space Physics, Boston University 725 Commonwealth Avenue, Boston, MA 02215, United States

The terrestrial ionosphere has four "classic layers" termed D, E, F1 and F2. At Mars, there are two distinct ionospheric layers that we call M1 and M2. In this paper we compare the electron densities of M1 and M2 measured by the Mars Global Surveyor (MGS) radio science experiment during 9-27 March 1999 with the electron densities of the terrestrial E and F1 layers derived from ionsonde data at six stations distributed around the globe. These ionospheric layers at the two planets are dominated by photochemistry, occur at similar atmospheric pressure levels, and their day-to-day variations are all linked to changes in solar activity. These variations provide the opportunity of making the first simultaneous study of four photochemical layers in the solar system. We introduce an "ionospheric layer index" to characterize ionospheric layers in general, and show that it varies between the M1, M2, E and F1 layers because different atmospheric chemistry and solar radiations are involved.

SA31A CC: 220 C-E Wednesday 0830h

Mars Space Weather and Upper Atmosphere Science III Posters *(joint with A, P, SH, SM)*

Presiding: **S Ledvina,** University of California, Berkeley**; J R Espley,** Rice University

SA31A-01 0830h POSTER

Modeling Space Weather Effects on the Middle and Upper Atmosphere of Mars

Natalie Curtis[1] (210-522-5573; ncurtis@swri.org); Geoff Crowley[1] (210-522-3475; gcrowley@swri.org); Chris Hackert[1] (210-522-4615; chackert@swri.org); David Hinson[3] (210-522-3475; hinson@rocc.stanford.edu); Gregory Wene[4] (210-522-5201; gwene@utsa.edu); Christopher Freitas[1] (210-522-2137; cfreitas@swri.org); Sidney Chocron[1] (210-522-3698; schocron@swri.org); Mark Bullock[1] (210-522-3475; mbullock@swri.org); Raymond G Roble[2] (303-497-1000; roble@hao.ucar.edu); Dan Boice[1] (210-522-3475; dboice@swri.org); Leslie A Young[1] (210-522-3475; layoung@swri.org); David Grinspoon[1] (210-522-3475; dgrinspoon@swri.org); Walter Huebner[1] (210-522-2730; whuebner@swri.org)

[1]Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78238-5166, United States

[2]High Altitude Observatory, NCAR, Mitchell Lane, Boulder, CO 80303, United States

[3]Stanford University, 350 Serra Mall, David Packard #333 Stanford University, Stanford, CA 94305-9515, United States

[4]University of Texas at San Antonio, 6900 N. Loop 1604, San Antonio, TX 78249, United States

We have created a new Mars GCM that extends from about 14 km above the planetary surface to altitudes of about 300km, thus coupling the lower and upper atmospheres. The model includes Mars-appropriate dynamics, chemistry, and energetics. Some preliminary results for a dust-free atmosphere are presented, showing temperature and composition profiles, electron density distributions, and global wind patterns. The simulations are validated against Mars Global Surveyor measurements of neutral density and temperature, and electron density. We examine modeled and measured space weather effects in the variability of the Mars atmosphere.

SA31A-02 0830h POSTER

Impact of Vertical Dust Distributions on the Structure and Dynamics of the Mars Upper Atmosphere : A Sensitivity Study using Mars TGCM Simulations

Jared M Bell[1] ((734) 994-0968; jmbell@umich.edu)

James Murphy[2] ((505) 646-5333; murphy@nmsu.edu)

Stephen Bougher[1] ((734) 647-3585; bougher@umich.edu)

[1]Department of Atmospheric, Oceanic, and Space Sciences University of Michigan, 2455 Hayward Street, Ann Arbor, MI 48109, United States

[2]Department of Astronomy, New Mexico State University, Las Cruces, NM 88001, United States

This research encompasses a study of the sensitivity of the Mars Thermospheric General Circulation Model (MTGCM) to vertical dust distributions in the lower atmosphere. Previous studies by Bougher et al (2003) have illustrated that including realistic lower atmospheric dust loading provides a more accurate portrayal of upper atmospheric dynamics. In particular, the observed polar warming during the latter part of Mars Odyssey's (ODY) Aerobraking Phase was largely reproduced by incorporating appropriate vertical dust profiles from the NASA Ames Mars General Circulation Model (MGCM) Murphy et al (2003). In the current simulations, we investigate the effects of modifying the Barney Conrath dust vertical mixing profiles on the resulting dynamics of Mars thermosphere. In addition, we use latitudinal and longitudinal variations in dust opacities from the Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES) Year One (1999-2000) and TES Year Two (2001-2002) data sets. Two primary benchmark cases are presented: Ls = 90, and Ls = 270, which correspond to MGS Phase 2 Aerobraking and the near end of Mars ODY Aerobraking. This sensitivity study represents a first step towards characterizing how dust storms may globally impact Mars' upper atmospheric regions.

SA31A-03 0830h POSTER

Low altitude low frequency magnetic oscillations at Mars

Jared R Espley[1] (713-348-2653; espley@rice.edu)

Paul A Cloutier[1] (pac@spacsun.rice.edu)

Greg T DeLory[2] (gdelory@ssl.berkeley.edu)

[1]Rice University, Dept. of Physics and Astronomy, Houston, TX 77005, United States

[2]Univ. of California, Berkeley, Space Sciences Laboratory, Berkeley, CA 94720, United States

Recently, general characterizations have been made of the magnetic oscillations observed in the Martian magnetosheath and below the magnetic pileup boundary. We expand upon that work to examine in detail the magnetic oscillations at the lowest observed altitudes. We find that low frequency magnetic oscillations at or below the proton gyrofrequency are consistently observed at altitudes as low as 200 km. We discuss the physical origin of these waves and what this implies about the plasma from which the waves originate. We also note the relevance of these waves in the exploration of the deep subsurface using inductive sounding techniques such as those found in magnetotelluric and magnetic gradiometry methods.

SA31A-04 0830h POSTER

3D multi-fluid simulations of the effect of dynamic solar wind conditions on the Martian magnetosphere

Erika M Harnett[1] (206-543-0212; eharnett@u.washington.edu)

Robert M Winglee[1] (206-685-8160; winglee@ess.washington.edu)

Carol Paty[1] (206-543-0208; cpaty@u.washington.edu)

[1]Department of Earth and Space Science, University of Washington Box 351310, Seattle, WA 98195, United States

Under quiet solar wind conditions, the strong surface magnetic field on Mars can modify the plasma inside the bow shock, and lead to the formation of mini-magnetospheres. The crustal magnetic field has no effect on the bow shock though. 3D multi-fluid simulations are used to study the effects of pressure pulses associated with storm conditions, on the structure of the inner Martian magnetosphere. The increased dynamic pressure of the solar wind pushes the bow shock closer to the surface, into a region where stronger magnetic fields can have substantial influence on the plasma. This can also lead to enhanced ionospheric outflow. Ionospheric outflow rates down the tail are calculated for a range of solar wind conditions and crustal magnetic field orientations.

SA31A-05 0830h POSTER

Predicting solar wind conditions at Mars

Craig D. Fry[1] (gfry@expi.com); Murray Dryer[2] (murray.dryer@noaa.gov); Wei Sun[3] (sun@jupiter.gi.alaska.edu); Charles S Deehr[3] (cdeehr@gi.alaska.edu); Syun-Ichi Akasofu[4] (sakasofu@iarc.uaf.edu); Susan McKenna-Lawlor[5] (stil@may.ie); David Lario[6] (david.lario@jhuapl.edu)

[1]Exploration Physics International, Inc., Suite 37-105 6275 University Drive NW, Huntsville, AL 35806, United States

[2]Space Environment Center, NOAA/SEC 325 Broadway, Boulder, CO 80305, United States

[3]Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775, United States

[4]International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK 99775, United States

[5]Space Technology Ireland, National University of Ireland, Maymooth Co. Kildare, Ireland

[6]Applied Physics Laboratory, Johns Hopkins University, Laurel, MD 20723, United States