Mars Neutral Upper Atmosphere Temporal and Spatial Variations Discovered from the Accelerometer Science Experiment aboard Mars Reconnaissance Orbiter.

G. M. Keating (g.m.keating@larc.nasa.gov)[1], S. W. Bougher[2], M. E. Theriot[1], R. H. Tolson[3], R. W. Zurek[4], R. C. Blanchard[1], J. R. Murphy[5], J. -L. Bertaux[6], [1]The George Washington University (The George Washington University, 1 Old Oyster Point Road, Suite 200, Newport News, VA 23602); [2]University of Michigan, Ann Arbor, MI; [3]National Institute of Aerospace, Hampton, VA; [4]Jet Propulsion Laboratory, Pasadena, CA; [5]New Mexico State University, Las Cruces, NM; [6]Service d'Aeronomie du Centre National de la Recherche Scientifique, France.

Introduction: This paper emphasizes the comparison of neutral atmospheric measurements above 100km observed from a series of accelerometer experiments aboard Mars Reconnaissance Orbiter (MRO), Mars Odyssey (MO), and Mars Global Surveyor (MGS). A number of spatial and temporal variations have been discovered including: day-night variations, latitudinal and seasonal variations, variations in vertical structure, variations in the polar region, variations with Mars-Sun distance, and variations with the 11-year solar activity cycle [1,2,4,5].

Accelerometer Experiment. Designed for aerobraking, Mars Reconnaissance Orbiter (MRO) launched on August 12, 2005, achieved Mars Orbital Insertion (MOI), March 10, 2006, and successfully completed aerobraking on August 30, 2006. Atmospheric density decreases exponentially with increasing height. By small propulsive adjustments of the apoapsis orbital velocity, periapsis altitude was fine tuned to the density surface that safely used the atmosphere of Mars to aerobrake over more than 400 orbits, providing more than 800 vertical structures. The location of MRO periapsis precessed from near the South Pole at 6pm Local Solar Time (LST) to near the equator at 3am LST. Meanwhile, apoapsis was brought in dramatically from ~40,000km at MOI to 480km at aerobraking completion (ABX). Without aerobraking, this would have required an additional 400kg of fuel. After ABX, two small propulsive orbital adjustment maneuvers September 5, 2006 and September 11, 2006 established the final Primary Science Orbit (PSO). Each of the aerobraking orbits provided, a pair of vertical structures inbound toward periapsis and outbound from periapsis, with a distribution of neutral atmospheric densities, scale heights, temperatures, and pressures along the orbital path, providing key in situ insight into various upper atmosphere (>100km) processes. One of the major questions for scientists studying Mars is: "Where did the water go?" Honeywell's substantially improved electronics package for its IMU (QA-2000 accelerometer, gyro, electronics) maximized accelerometer sensitivities at the requests of The George Washington University, JPL, and Lockheed Martin. The improved accelerometer sensitivities allowed density measurements to sometimes exceed 200km, at least 40km higher than measurements with Mars Odyssey (MO). This extends vertical structures from MRO into the neutral lower exosphere, a region where various atmospheric processes may allow atmospheric gases to escape.

Results and Discussion. Comparisons between MRO and MO accelerometer measurements of Mars upper atmospheric density show large solar minimum to maximum changes and large solar distance effects. Winter polar warming discovered by the accelerometer measurements is much weaker near the South Winter Pole (aphelion) than near the North Winter Pole (perihelion). This is probably due to the weaker solar input near aphelion resulting in a weaker meridional circulation inducing a weaker adiabatic heating at the South Winter Pole than at the North Winter Pole. High amplitude +-20% Kelvin waves are detected on the nightside. Strong latitudinal and seasonal variations are detected. Day/night variations of a factor of 3 are observed. Excellent agreement between MRO climatology (2006) and previous Mars Express (2004) climatology from SPICAM stellar occultations of density has been discovered [3,4].

References:

[1] G.M. Keating et al., Atmospheric Structure from Mars Reconnaissance Orbiter Accelerometer Measurements. Proceedings of Europlanet #1 European Planetary Science Congress, Berlin, Germany, 18-22 September 2006.

[2] G. M. Keating et al., Mars Reconnaissance Orbiter: Aerobraking Science Discoveries Using the Accelerometer. Division of Planetary Sciences Meeting of the American Astronomical Society, session 73: Mars V: Upper and Lower Atmosphere, Pasadena, California, 8-13 October 2006. **Bulletin of the American Astronomical Society**, Volume 38, #3, page 631, 2006.

[3] M. Theriot et al., Interannual Comparison of Temporal and Spatial Structure in the Martian Thermosphere from Atmospheric Accelerometer Measurement of Mars Reconnaissance Orbiter (MRO) during Aerobraking and Stellar Occultation Measurements from the SPICAM Ultraviolet Infrared Atmospheric Spectrometer of Mars Express. Division of Planetary Sciences Meeting of the American Astronomical Society, session 73: Mars V: Upper and Lower Atmosphere, Pasadena, California, 8-13 October 2006. **Bulletin of the American Astronomical Society**, Volume 38, #3, page 630, 2006.

[4] G.M. Keating et al., Initial Mars Upper Atmospheric Structure Results from the Accelerometer Science Experiment aboard Mars Reconnaissance Orbiter, Proceedings of 2006 AGU Fall Meeting, P33A: Mars Reconnaissance Orbiter II: A New Look at Mars, San Francisco, California, 11-15 December 2006.

[5] R.W. Zurek et al., Mars Reconnaissance Orbiter, An Overview of Early Results and Plans for Further Observation, Proceedings of 2006 AGU Fall Meeting, P33A: Mars Reconnaissance Orbiter II: A New Look at Mars, San Francisco, California, 11-15 December 2006.