RESULTS FROM RADIO OCCULTATIONS WITH MGS.

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The Sun-synchronous, polar orbit of Mars Global Surveyor (MGS) provides frequent opportunities for radio occultation experiments, which are conducted routinely as part of the Radio Science (RS) investigation. These experiments sound the atmosphere by measuring its effect on the propagation of coherent microwave radiation. The basic result of each experiment is a profile of pressure and temperature versus planetocentric radius and geopotential. Roughly 6000 profiles spanning more than 2 Martian years have been obtained to date, and additional observations are underway. The retrieved profiles are accessible through the MGS RS Web site (http://nova.stanford.edu/projects/mgs/public.html).

Our recent analysis of MGS RS data has focused on planetary-scale "eddies," including stationary planetary (or Rossby) waves and transient eddies. These planetary-scale eddies are prominent at mid-to-high latitudes in the fall, winter, and spring seasons of the respective hemispheres. Stationary waves are excited primarily by topographic forcing of the basic zonal flow, while transient eddies can arise from instability associated with strong meridional temperature gradients.

Planetary-scale eddies are an important component of the Martian climate system. Eddy fluxes of heat and momentum influence the general circulation, while eddy advection modifies the horizontal distributions of dust and water vapor. The notable seasonal variations and hemispheric asymmetries in their behavior makes these eddies an intriguing component of the seasonal cycles of water and dust.

Radio occultations play a unique role in characterizing these eddies by resolving their structure (temperature, geopotential height, and meridional winds) in the lowest scale height above the surface. RS measurements in the mission to date have revealed non-negligible meridional winds and strong meridional heat fluxes within this region.

Other researchers are using nadir observations by the MGS Thermal Emission Spectrometer (TES) to obtain a broad empirical description of planetary-scale eddies with complete seasonal and global coverage. The emphasis here is on deeper investigation of their behavior at selected seasons in each hemisphere. Our approach involves a combination of data analysis with simulation by a Mars general circulation model, which can yield a far more thorough characterization than has been obtained previously. We rely primarily on RS profiles, but we have also begun to use selected TES limb profiles.

As an example of this approach, we recently reported new observations of stationary planetary waves in the southern hemisphere [D. P. Hinson, R. J. Wilson, M. D. Smith, and B. J. Conrath, JGR-Planets, in press, 2003]. We focused on a period during midwinter ($L_s = 134°$–$160°$) when independent observations were acquired by two techniques. The RS experiments sounded the atmosphere at essentially fixed latitude (~68°S) and local time (~1030), yielding profiles of geopotential and temperature between the surface and the 9-Pa pressure level. TES observations included systematic limb sounding at nine discrete latitudes and two local times (~0200 and ~1500), yielding temperature profiles at pressures of 1–100 Pa. We supplemented these data with a simulation by a Mars general circulation model, which provides an accurate synthesis of the observations. These stationary planetary waves have significant amplitudes at zonal wave numbers $s = 1$ and 2. The $s = 1$ component propagates vertically, as reflected by a westward tilt with increasing height in the geopotential and temperature fields and a net poleward eddy heat flux. The peak amplitude at $s = 1$ is ~1 km in geopotential height and ~7 K in temperature. The geopotential field of the $s = 2$ component is "barotropic" in character, which results through hydrostatic balance in a distinctive temperature field. The peak amplitude at $s = 2$ is ~700 m in geopotential height and 4–6 K in temperature.

The same set of RS measurements provided the first observations of transient eddies in the southern hemisphere of Mars [D. P. Hinson and R. J. Wilson, GRL, 29(7), 10.1029/2001GL014103, 2002]. The dominant mode has a period of ~2 solar days and a zonal wavenumber $s = 3$. Strong zonal variations in eddy amplitude signal the presence of a possible "storm zone" at 150°–330°E longitude. Within this longitude band the eddies achieve peak amplitudes at the 300-Pa pressure level of ~7 K in temperature and 10–15 m s^{-1} in meridional wind speed. The minimum temperature associated with the eddies is ~2 K colder than saturation of CO_2, close to the threshold where nucleation and growth of new ice particles can occur. A simulation by a Mars general circulation model produces traveling eddies that closely resemble the observations.

An analogous effort to characterize and simulate planetary-scale eddies in the northern hemisphere is underway.