will also be crucial to a GCM resulting from the GEM program.

Models have described several aspects of convection patterns observed in the polar-cap ionosphere. Models that quantitatively predict the polar-cap convection pattern as a function of the IMF can be compared with GEM observations. Figure 4 shows preliminary results from the Aerospace/Schulz source-surface model for both polar caps for 1520 UT on January 27, 1992. In each panel, the heavy closed curve is the model separatrix and light curves are equipotential contours spaced 10 kV apart. These results can be compared to the observations for this time (Figure 1).

For example, the shape of the model potential contours within the open-field-line region is similar to the AMIE results. The model predicts a region of enhanced flow near noon that moves toward the post-noon side in the Northern Hemisphere and toward the pre-noon side in the Southern Hemisphere which is also seen in the AMIE results as well as the empirical convection patterns of *Heppner and Maynard* [1987].

The model also performs ionospheric mapping of the magnetospheric cusp (or cleft) (see Figure 4). The region between the separatrix and the cleft is thought to be the dayside low-latitude boundary layer. A mapping of this boundary region along the magnetospheric flanks to the polar caps is also shown in Figure 4. In the model, a portion of this region lies on open field lines that cross the equatorial plane and map to the polar caps for an IMF with a northward-directed component. We will compare boundary layer, separatrix, and potential pattern predictions from models, such as those in Figure 4, to results from the GEM campaigns.

If you wish to participate in planning additional campaigns, contact one of the authors of this article.

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New Gravity Field for Mars Fuels Research

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An new gravitational field model for Mars sheds new light on the structure and composition of many short-wavelength features on the planet's surface. The model, Goddard Mars Model-1 (GMM-1) (Figure 1), holds great promise for future Mars research.

Besides resolving more short-wavelength features than previous Mars gravity models, most major features have higher magnitude anomalies. For example, GMM-1 details the Valles Marineris canyon near the center of the map and reveals structures of several major impact basins and shield volcanos never before observed. Interestingly, several prominent anomalies in GMM-1 fail to correlate with surface features. Two prominent anomalies of this type in the northern hemisphere (lon=-160°, lat=+30° and lon=105°, lat=+50°) may indicate features covered by volcanic flooding.

GMM-1 has also found that Mars' gravity anomalies correlate well with the major features of the planet's topography, in contrast to Earth where the gravity and topographic fields are not strongly correlated. Knowledge of the gravitational field of a planet, in combination with surface topography, provides information about its interior makeup. By removing the gravitational attraction of topography, it is possible to study the distribution of density anomalies within the planet. Density anomalies provide information on the planet's internal temperature and composition. Gravity is determined by measuring the Doppler shift of the signal used to track the spacecraft. Differencing the Doppler measurements yields the acceleration in the line-of-sight between the spacecraft and Earth. The accelerations that remain after spacecraft position and other corrections have been applied are due to gravity. Deviations from a reference value represent anomalies indicating excesses and deficiencies in subsurface mass.

Gravity measurements for Mars were derived by tracking three orbiting spacecraft: Mariner 9 from 1971–1972 and the Viking 1 and 2 orbiters from 1976–1979. The tracking data from these spacecraft were processed and assembled into global representations of the gravity field [cf. *Esposito et al.*, 1992], with the highest resolution field determined by *Georges Balmino et al.* [1982] at 600 km.

These early global representations of the

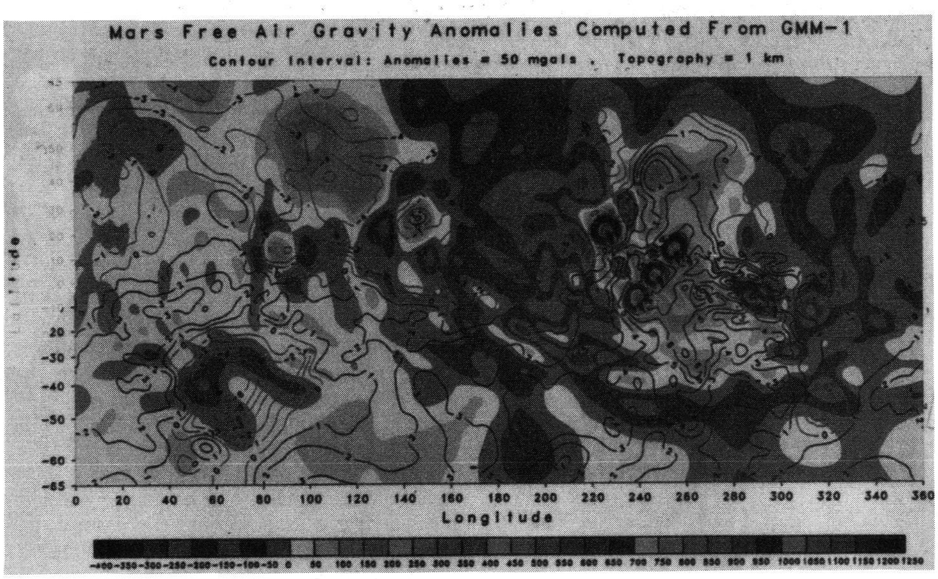

Fig. 1. Free-air gravity anomalies from Goddard Mars Model-1 (GMM-1) shown as colored contours at the same resolution as the gravity field. Original color image appears in the back of this volume.

gravity field were imprecise for several reasons. The spatial resolution of the data is uneven because all three spacecraft were in elliptical orbits with periapsis altitudes and orbital inclinations that changed during the missions. And the maximum resolution of Balmino's model was limited by the computer facilities available.

Because computational resources are no longer a limitation, we reprocessed all of the Mariner and Viking tracking data to develop GMM-1 [*Smith et al.*, 1993]. In addition to using a more capable computer and incorporating additional tracking data, we applied a numerical solution technique used in the derivation of terrestrial gravity models called least squares collocation, which derives a global field resolving features locally at the limit of resolution. Figure 1 also shows that the gravity anomalies correlate well with the major features of Martian topography, in contrast to Earth where the gravity and topographic fields are not strongly correlated. On Mars, the topography is held up by internal density anomalies and/or forces due to flow in the mantle.

Even with the improved gravitational field geophysicists do not understand aspects of the Martian interior, such as the thickness of the crust, the temperature structure of the mantle, and the size and density of the core. Research is limited by the variable resolution of the gravity data and the lack of accurate topographic knowledge of the planet. Experiments to obtain high-resolution gravity and topography data were included on the Mars Observer spacecraft, which was lost just before insertion into Mars orbit in August 1993.

Plans are in place to recover the Mars Observer science objectives through a follow on mission with single or multiple spacecraft. Such a mission would map the surface from a ~400-km altitude polar orbit and provide data to enhance understanding of the structure of the interior of Mars.—*D. E. Smith and M. T. Zuber, Laboratory for Terrestrial Physics, NASA/Goddard Space Flight Center, Greenbelt, Md.; Zuber also at Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, Md.*

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Geoscience Information Society Award

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The Geoscience Information Society (GIS) has announced the creation of the GIS-Mary B. Ansari Best Reference Work Award. The award is funded by a gift of $5000 from former GIS President Mary B. Ansari, currently Director for Branch Libraries and Library Administrative Services at the University of Nevada, Reno. The Best Reference Work Award has been given annually for 7 years, but now the GIS will begin to present the winner with a monetary award.

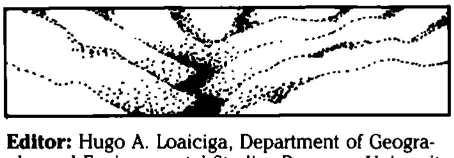
The award will be $500 per year and will be presented to the author or editor of the geoscience reference work selected for the award. The money will be divided equally in cases of multiple authors.

The GIS is an international non-profit professional society established in 1965 to improve the exchange of geoscience information by encouraging interaction and cooperation among scientists, librarians, editors, cartographers, educators, and information professionals.

For more information about the award, contact Dena Fracolli Hanson, GIS Publicity Officer, 3110 McPherson Ave., Fort Worth, TX 76109; tel. 214-708-6095; fax 214-708-0016.

SECTION NEWS

HYDROLOGY



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Evaluating Climate Change Impacts in Snowmelt Basins

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The implications of global climate change for hydrology and water resources are likely to be complex, widespread, and significant for both natural ecosystems and society. Yet our understanding of these implications remains rudimentary despite considerable effort and research over the last decade. One of the most difficult hydrologic problems in this area is evaluating the impacts of climate change in hydrologic basins affected by snowfall and snowmelt, especially high-latitude and high-altitude watersheds. Many of these watersheds are the headwaters for major rivers and they often provide substantial amounts of water for human and ecosystem use. Evaluating the impacts of climate change in these basins will help us better understand how to improve the management and protection of our water resources systems. In April 1993, a roundtable workshop was held in Santa Fe, N. Mex., to discuss hydrologic models for evaluating the impacts of climate change in snowmelt basins.

The U.S. Agricultural Research Service (ARS) and the Pacific Institute for Studies in Development, Environment, and Security, in Oakland, Calif., convened the workshop. Its goals were to discuss the history of modeling snowmelt basins, the state-of-the-art of hydrologic modeling, to consider suggestions about research paths and goals, and to identify critical research tasks and collaborative projects to better address the problem. Ultimately, if public policy and water resources planning and management are to benefit from the use of hydrologic models in evaluating the impacts of global climate change, we must improve our ability to understand the implications of greater uncertainty and include these uncertainties in our water management.

The workshop maximized interaction among the participants and permitted discussion of specific modeling approaches and needs. A wide range of current model approaches were reviewed, and participants discussed their former uses and how they should be applied. Summaries were given of the recent World Meteorological Organization hydrologic model intercomparison projects and work modeling the impacts of climate change on the upper Colorado and Rio Grande rivers and the American and Carson rivers in the Sierra Nevada, Calif. Details of how to apply specific models such as the HYDROTEL, SLURP, NWSRFS, PRMS, and SRM models to the problem of climatic change, the use of regression equations for runoff modeling, and dynamic land surface/atmosphere parameterizations at different spatial scales were also discussed.

Among the principal points gleaned from the presentations were the importance of temperature sensitivity of the snow regime, distribution of precipitation as a function of

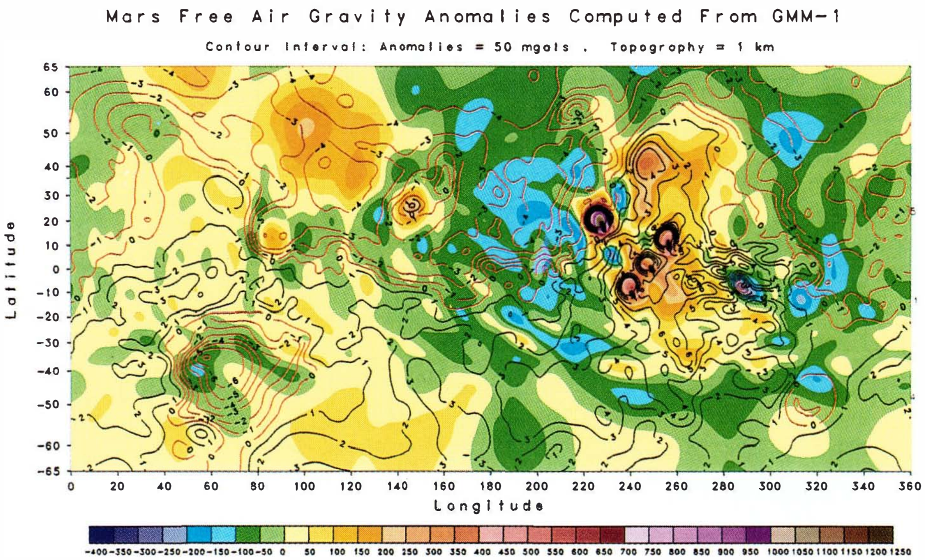

Fig. 1. Free-air gravity anomalies from Goddard Mars Model-1 (GMM-1) shown as colored contours. Also shown for comparison is the current Mars topography field displayed as line contours at the same resolution as the gravity field.