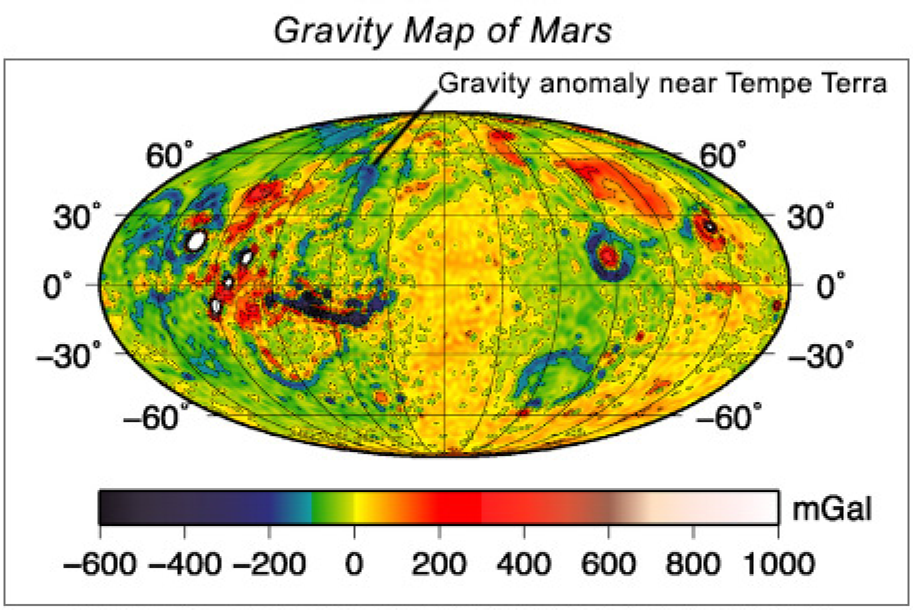
Mars Gravity, Tides, and Love Number

The tried and true technique, unique to the space age, of using perturbations in the paths of orbiting spacecraft to monitor the forces acting on the spacecraft is refined again for Mars. Antonio Genova (Massachusetts Institute of Technology and NASA Goddard Space Flight Center) and colleagues from MIT, Goddard, and the University of Maryland have expertly exploited 16 years of radio tracking data of three NASA spacecraft orbiting Mars to model the planet's static (long-term average) and time-varying gravity field.

Static Gravity Field and Interior Structure

Using the entire Mars Global Surveyor radio tracking data set (1999-2006) with Mars Odyssey and Mars Reconnaissance Orbiter radio tracking data until 2015, the team was able to improve the model of the Mars gravity field over predecessor models.

They accounted for, and improved the accuracy of, numerous details affecting the spacecraft in addition to gravitational forces, such as atmospheric drag, solar radiation pressure, and even perturbations on the orbits caused by the satellites' own attitude control maneuvers and antenna offsets.



(Genova *et al.*, 2016, *Icarus*, **272**, 228-245. MIT/UMBC-CRESST/GSFC.)

The Goddard Mars Model 3 gravity map by Genova and colleagues, showing gravity anomalies. Arrow points to the gravity trough near Tempe Terra—the new, higher-resolution gravity data show more clearly that this is associated with the highland-lowland dichotomy boundary. Genova and coauthors suggest this gravity anomaly is a density contrast in the crust or mantle related to deformation by Tharsis volcanism. Click for higher resolution verison and more information from NASA.

As a result of the new gravity data (known as Goddard Mars Model 3), sharper definitions of previously-known gravity anomalies on Mars have led to new interpretations (see figure and caption). For example, Genova and colleagues suggest the gravity low near Tempe Terra (arrow) is larger than previously determined. Its western edge tracks a topographic contour of the highland-lowland dichotomy boundary and its eastern section runs perpendicular to the local topographic slope. This gravity trough, once attributed to a system of buried outflow channels, is now interpreted by Genova and colleagues as a density contrast in the crust or mantle related to deformation by Tharsis volcanism. The resulting upgrade in the correlation between global gravity and topography has also led to better estimates of the crustal thickness of Mars.

Time-varying Gravity Field and CO_2 Cycling

Variations in the Martian gravity field are used to better understand phenomena that redistribute mass, and the longer the time span of the data set the better. Genova and coauthors used their new, high-resolution model of the time-varying gravity field to improve our understanding of the mass variations of the Martian polar caps—hugely significant to global climate science on Mars. These changes in mass are due to redistribution of CO_2 in a seasonal cycle of condensation and sublimation in the north and south ice caps. Yes, it snows CO_2 during the polar winter night (see Paul Hayne's article for the Planetary Society: ***Dry Ice Snowfall at the Poles of Mars***), but did you know that four trillion tons of CO_2 cycle annually between the Martian poles? (See Bill Steigerwald's NASA news article: ***New Gravity Map Gives Best View Yet Inside Mars***.)

Tides and the Martian Love Number

Martian solid tides raised by the Sun and Phobos also cause redistribution of mass and were investigated by Genova and colleagues. Their work led to a new solution of the tidal Love number, which describes the elastic response of the planet to the tidal potential (how much the shape of the planet changes or bulges). The new gravity field data and tidal Love number allowed Genova and coauthors to confirm Mars' molten outer core.

See Reference:

· Genova, A., Goossens, S., Lemoine, F. G., Mazarico, E., Neumann, G. A., Smith, D. E., and Zuber, M. T. (2016) Seasonal and Static Gravity Field of Mars from MGS, Mars Odyssey and MRO Radio Science, *Icarus,* v. 272, p. 228-245, doi: 10.1016/j.icarus.2016.02.050. [***abstract***]

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