NASA Office of Space Science Education and Public Outreach Conference 2002
ASP Conference Series, Vol. 319, 2004
Narasimhan, Beck-Winchatz, Hawkins & Runyon

Schmidt Crater: Making Data from the Mars Global Surveyor Accessible to Introductory Astronomy Students

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Introduction

Like 200,000 other college students nationally, a typical astronomy student at Sinclair Community College is a non-science major taking astronomy to satisfy a general-education science requirement for the Bachelor's degree. Images from the Mars Orbiter Camera (MOC) and data from the Mars Orbiter Laser Altimeter (MOLA) are the basis for a series of lab activities that engage these students in investigating the Schmidt Crater region, near the South Pole of Mars.

Goals of the Project

In cooperation with faculty from mathematics, geography, and sociology, the author developed a set of new lab activities that (a) enhance students' understanding of contemporary explorations of the solar system, (b) increase students' ability to use scientific reasoning and basic math skills to answer realistic questions, and (c) encourage students to make more detailed comparisons between Earth and Mars. The activities are also intended to be low-cost, to be suitable for either on-campus or distance-learning environments, and to be fun for both students and instructors.

Methodology

Schmidt Crater was selected as a region on Mars about which students have little or no advanced knowledge but which is similar in size to a familiar object – the state of Ohio. Altimeter data for the region were extracted from the MOLA PEDRs, Volumes 2010 through 2054 (Smith et al. 1999). Wide and narrow angle photos of the region were obtained from the Planetary Data System web site (Malin et al. 2003). Using Perd2tab, ArcView, and other software, the data and images were converted to forms that introductory, non-science students can use without the need for expensive or highly specialized software. The activities were tested during the spring and fall of 2001 and are being revised to incorporate data from Mars Odyssey. Students use free software (Scion Image [Scion Corporation 2004] or ArcExplorer [ESRI 2004]) and print materials to interpret images and data both qualitatively and quantitatively. They complete a series of "authentic learning tasks" related to planning for a permanent base near Schmidt Crater.

Sample Activities

Maps and Coordinate Systems. Coordinate systems are an important topic in introductory astronomy, and one that many students find difficult. The astronomer's system of right ascension and declination is traditionally described as a projection onto the sky of latitude and longitude, and teaching Einstein's ideas about relativistic space-time warps also depends upon an analogy with latitude and longitude. Unfortunately, only a few students begin college astronomy classes familiar with map coordinate systems. The Schmidt Crater region provides an opportunity to build the students' skills in quantitative analysis of locations, elevations and displacements within an environment that is small enough to seem familiar but large enough to show distinct effects of the planet's curvature. Students use the GIS program, ArcExplorer, and printed maps to plan a pipeline to potential water sources in the high plateaus south of Schmidt Crater. They also investigate possible transportation links to a polar research station.

Interpreting Data. Assessing the quality of data is an essential skill for scientists and for everyone else. Unfortunately, introductory science students typically do little more than calculate a "percent error" for some of their own measurements. They frequently ascribe any shortcomings to "student error" or "faulty equipment," and assume that "real" scientists with "real" equipment never have to worry about such things. Even with the best possible equipment, of course, it is extremely difficult to collect, validate and disseminate over half a billion high-precision MOLA measurements. The data quality is amazingly good, but one incident provided an opportunity to engage students in a quantitative analysis of the MGS orbit and to give them a more realistic view of the difficulties faced by scientists. When preliminary data from December of 2000 were added to our set, a new "fault line" suddenly appeared. It turned out the data in question was collected on Christmas Day, when only one of the usual three tracking stations was monitoring the satellite. For 18 hours, MGS was on its own and the quality of the data suffered.

Where Do You Want to Live? Using MGS data and GIS software to answer Earth-like questions provides a way to engage introductory college students in testing the limits of our current knowledge about Mars. Most key locations (including that of "Schmidtville") were selected to make use of narrow-angle photos from the Mars Orbiter Camera. As a potential "homestead," students also investigate a 4-km^2 area for which there is no narrow-angle photo. The 38 MOLA hits provide important details, but many questions remain. Are there really 4 separate peaks in the lower left of the homestead, or is it an artifact of the cartographer's interpolation method? What do we really know about this small area of Mars, and what else would you like to know?

Frontiers of Knowledge. Even before Odyssey provided new evidence for the presence of subsurface water ice on Mars, students were looking at the "pitted terrain" south of Schmidt Crater as a potential source of water. In the activities, students made comparisons with water use on Earth and in the International Space Station to estimate the water needs of a colony on Mars. They also made comparisons with the permafrost and the glaciers of Alaska to estimate the quantity of water available. The very first Odyssey image provided important new information about the temperature variations associated with the pitted

terrain. The early results from Odyssey's epithermal and high-energy neutron spectrometers provided evidence that water ice is likely to be present beneath the entire Schmidt Crater region. The use of GIS software made it very easy to integrate the new data with the old.

Conclusion

Data sets from the Mars Global Surveyor provide a wide variety of opportunities to engage general-education astronomy students in quantitative investigations near the frontiers of planetary exploration. The compilation and translation of data into forms appropriate for use with low-cost or free software (such as ArcExplorer and Scion Image) can greatly expand the educational uses of the data, both by allowing faculty to produce new print materials and by allowing students to interact directly with the data.

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