COMPARISON OF ATMOSPHERIC OBSERVATIONS AND PREDICTIONS FOR THE ATMOSPHERIC ENTRIES OF SPIRIT AND OPPORTUNITY. Paul Withers[1], J. R. Barnes[2], C. G. Justus[3], H. L. Justh[3], D. M. Kass[4], L. Montabone[5], and S. C. R. Rafkin[6], [1]Center for Space Physics, Boston University, 725 Commonwealth Avenue, Boston, MA 02215, USA, withers@bu.edu, [2]College of Oceanic and Atmospheric Sciences, Oregon State University, [3]NASA Marshall Spaceflight Center, [4]Jet Propulsion Laboratory, [5]Department of Physics and Astronomy, Open University, Great Britain, [6]Southwest Research Institute.

Introduction: Many models were used to make atmospheric predictions for the landings of Spirit and Opportunity. We shall compare those predictions to atmospheric density, pressure and temperature profiles observed during the landings of Spirit and Opportunity. This will help estimate the likely accuracy of similar predictions for future Mars landers, including Mars Science Laboratory.

Available Predictions: Predictions are available from empirical models and physics-based models. Empirical models include the Kass-Schofield model [1], which is based on MGS TES T(p) data, and the MarsGRAM model [2,3]. Physics-based models include the European Mars Climate Database produced by the Oxford/LMD Mars General Circulation Model [4], the Mars Regional Atmospheric Modeling System (MRAMS) [5] and the Oregon State University Mars Fifth-Generation Penn State/NCAR Mesoscale Model (OSU MMM5) [6]. Some of these models, such as MRAMS, were primarily used to predict winds, not to predict the mean density.

Available Data: Spirit and Opportunity data have been used to determine vertical profiles of atmospheric density, pressure and temperature at the times and locations of each landing (Figure 1) [7]. MGS TES T(p) profiles near each landing site are available near the time of each landing [7].

Justification of this Work: Predictions of atmospheric conditions affect million-dollar hardware decisions for Mars landers. They also influence modifications to software that controls entry, descent and landing (EDL). These modifications are made frequently between launch and EDL. Such predictions also affect landing site selection. If atmospheric densities are considered to be too variable, and thus unpredictable, at a candidate landing site, then the candidate site will not be chosen. Expected winds and wind shear concern mission engineers as well.

Given these considerations, it is useful to determine the likely accuracy of atmospheric predictions made for future Mars landers. There are many ways to do this. One way is to compare atmospheric predictions for previous Mars landers to actual data.

Scientific Rationale: By determining which models are most accurate and the altitude regions in which models are accurate/inaccurate, we will be able to hypothesize about what physical processes are improperly represented in the models. For example, models that use real-time TES dust data may be more accurate than those that use dust data from earlier Mars years. For example, empirical models may be more accurate than physics-based models, which would suggest that the physics-based models need either better physics or better boundary conditions.

Many predicted profiles of density as a function of altitude, which is of critical importance to mission design, depend on extrapolated surface pressure data from Viking. Those provided by empirical models based on TES T(p) data need a reference surface pressure to give an absolute altitude scale. If the extrapolated surface pressure is not accurate, the predicted density/altitude profile is not accurate either. The comparisons performed in this project are an indirect way of testing whether that extrapolation is accurate or not.

The conversion of temperature profiles into density profiles is very sensitive to systematic biases in temperature. For example, a 5% bias in temperature accumulates to a 25% error in density over 5 scale heights (approximately 40 km).

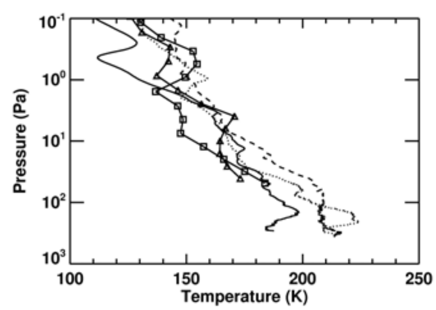

Figure 1. Entry profiles from Viking Landers 1 and 2, Pathfinder, Spirit and Opportunity. Squares are Viking 1, triangles are Viking 2, unmarked solid line is Pathfinder, dashed line is Spirit and dotted line is Opportunity. Uncertainties are not shown. From [7].

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