



# Mars' Atmosphere: Comparison of Entry Profiles with Numerical Models

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## Introduction

As planetary probes enter an atmosphere, they capture measurements which provide thermodynamic information about the atmosphere, but only within a narrow vertical column within that atmosphere over a limited extent of time. In order to place this in situ information into context, it needs to be correlated with other less spatially resolved but more temporally extensive measurements, which can be provided by orbiters as well as numerical models. Before the entry probe is designed and developed, there needs to be some foreknowledge of conditions the probe will experience. Data from previous probes and orbiters can help, and models can aid by permitting investigation of conditions the orbiters may not have observed.

Focusing on Mars, there are now six entry profiles available for analysis and interpretation, as well as a decade's worth of remotely sensed atmospheric thermal and aerosol characterization from orbiting platforms. Additionally, there are one-dimensional (vertical) and three-dimensional numerical models of the atmosphere available to provide predictions for entry probes [1,2,3] (and aerobraking spacecraft [4]) and to aid in interpretations of entry probe measurements.

This presentation focuses upon the atmospheric variability that can be experienced by a probe, which has a dependency on atmospheric dust load, season, location (latitude and longitude), and "weather" (baroclinic waves, thermal tides, dust storms, etc.) The primary tool is a numerical model of the Martian atmosphere with significant heritage (NASA AMES GCM), with additional comparison to a new model in development with collaboration with the University of Michigan.

## Profile Derivations

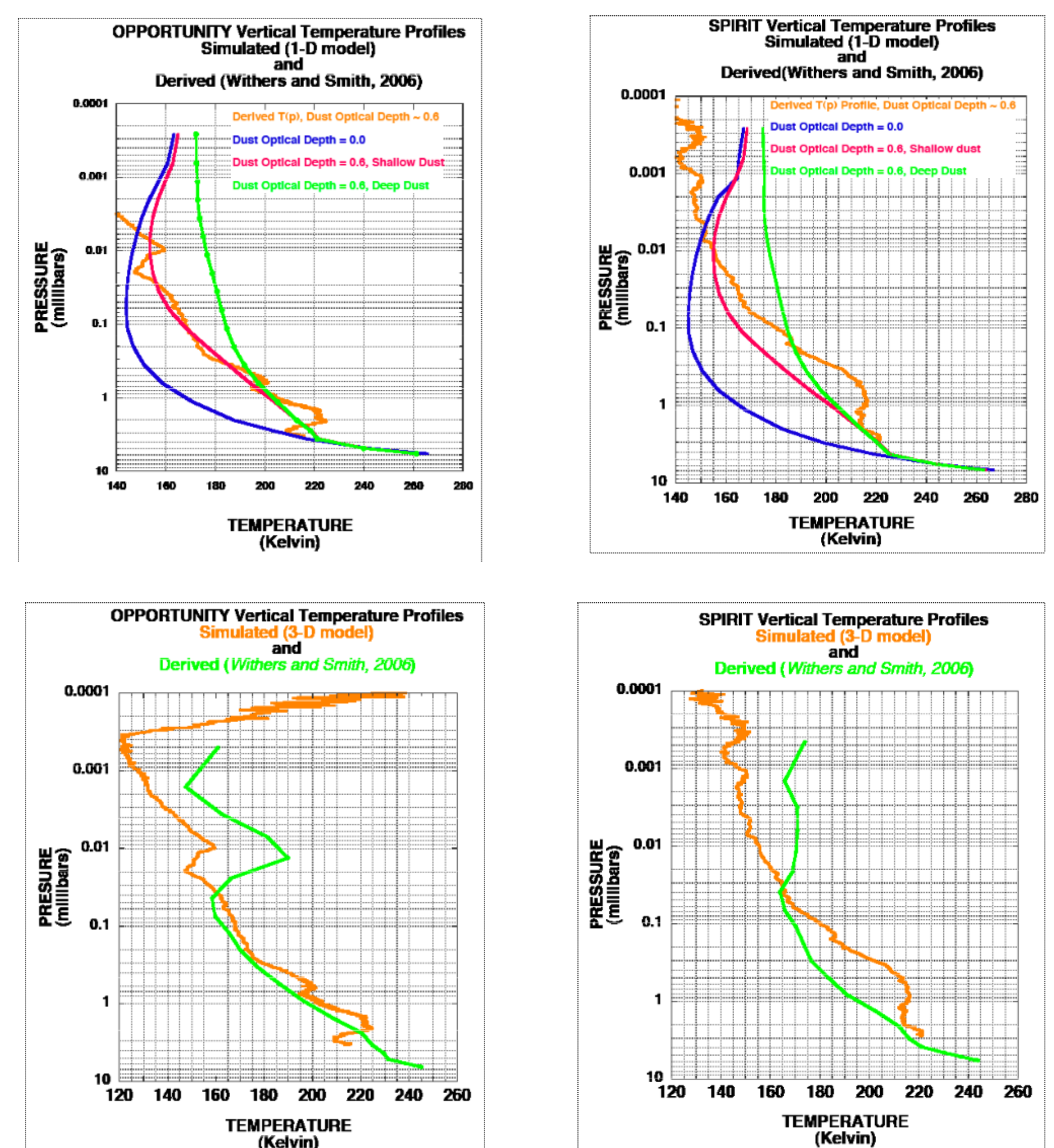
The atmospheric profile derivations used in this project were recreated using software made by Dr. Paul Withers. For comparative purposes we did an atmospheric density profile derivation from the data collected by Opportunity using data available from the PDS Atmospheres node. For this derivation we used the equation  $\rho = 2ma_z / Av^2C_A$ , where  $\rho$  is the atmospheric density,  $m$  is the mass of the Rover entry vehicle,  $a_z$  is the downward acceleration of the entry vehicle,  $A$  is the cross sectional area of the entry vehicle orthogonal to the descent path,  $v$  is the velocity of the entry vehicle with respect to Mars in the direction of travel, and  $C_A$  is the high speed drag coefficient of the Rover entry vehicle. Information such as the mass of the spacecraft was taken from [8]. Other quantities were derived using basic kinematic equations.

## Preliminary Conclusions

From the work that we have done it is apparent that there is a significant correlations between the vertical dust distribution and atmospheric thermodynamic properties. As of yet there are still more factors to be investigated when looking at thermodynamic properties of the atmosphere. In the future of this project we plan to look even more closely at the effects of atmospheric dynamics, vertical dust mixing, and year to year variation. This will provide for the MERs what Haberle et al. (1999) did for the Mars Pathfinder Lander.

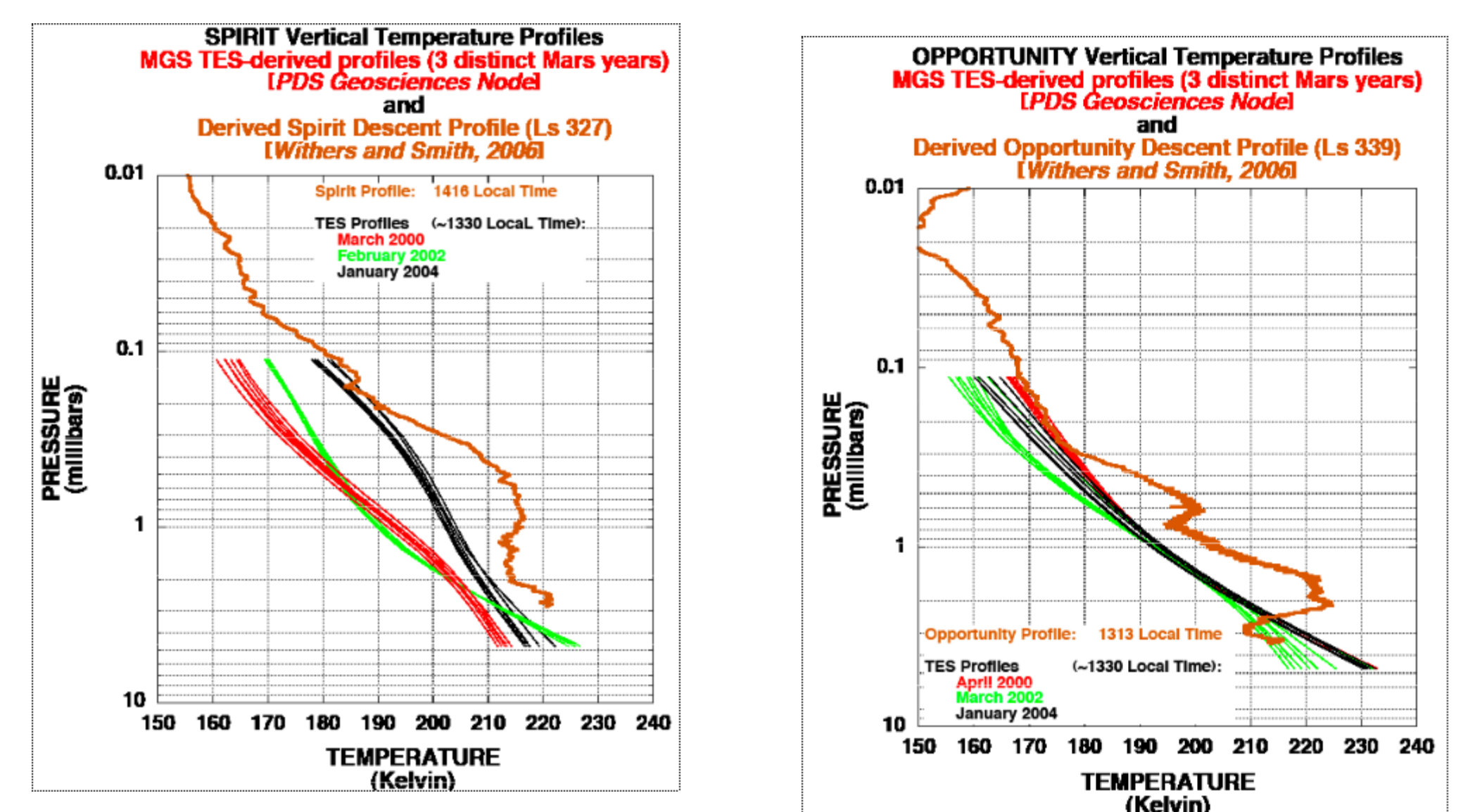
## Model Comparisons

In order to gain insight about the dust content and distribution of the Martian atmosphere during these LS times we ran two different kinds of model simulations. The first kind was a 1-Dimensional model that only took into consideration the atmospheric dust content and its vertical distribution and radiative transfer impact [5]. The second model was a 3-Dimensional model that also took dynamics into consideration [6].



## Comparison With TES Data

We made comparisons of the Rover entry temperature profiles to temperature profiles derived using infrared measurements from the Thermal Emission Spectrometer (TES) on board the Mars Global Surveyor Spacecraft [7]. The measurements from the Thermal Emission Spectrometer that we used were taken during the same Ls values as the Rover landings ( $\pm 5$  degrees), and the TES data fall within a  $\pm 5$  degree region of each of the landing sites (latitudinally and longitudinally).



## References

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