MARTIAN ATMOSPHERIC DUST PROPERTIES RETRIEVED USING A SENSITIVITY MATRIX METHOD. A. Elteto[1] and O. B. Toon[1], [1]Laboratory for Atmospheric and Space Physics (University of Colorado, UCB 392, Boulder, CO 80309, Attila.Elteto@colorado.edu)

Introduction: Atmospheric dust serves both as an important radiative agent in the Martian atmosphere, as well as a diagnostic tracer of atmospheric processes. Past observations [1,2,3] and global circulation models [4,5,6] have shown various trends in dust optical depth and particle size. This project presents a dust property retrieval algorithm from Mars Global Surveyor Thermal Emission Spectrometer (MGS TES) data using a sensitivity matrix method. We will compare our result to those from other retrievals.

Model Description: We use a radiative transfer code [7] to model upwelling radiance from the atmosphere, as would be observed by TES. We vary the input physical parameters such as dust optical depth, particle size, and surface temperature to construct a spectral response sensitivity matrix. We compare our model radiance to data, and use the difference, as well as our knowledge of spectral response to retrieve a new set of parameters and produce a better model fit to the data.

Sensitivity Matrix. Sensitivity ($C_{q,\nu}$) at selected wavenumbers (ν) is calculated to first order by varying input parameters (q) and observing the spectral response (ΔT_ν):

$$\Delta T_{B,\nu} = T_{B,\nu} - T_{B,o,\nu} = C_{q,\nu}(q_\nu - q_o)$$

The sensitivity matrix is coupled to the parameters, hence the sensitivity matrix needs to be explored for a range and combination of parameter values.

By studying the sensitivity matrix we can deduce which parameters can be uniquely distinguished based on their spectral response and hence can be retrieved, and which parameters cannot be retrieved.

Data comparison and new parameter retrieval.

The sensitivity matrix allows us to retrieve parameters in TES data.

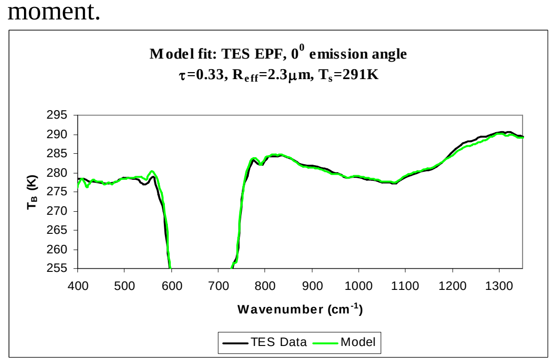
$$\Delta T_{B,\nu} = T_{B,data,\nu} - T_{B,model,\nu} = C_{Q,\nu}(q_{data} - q_o)$$

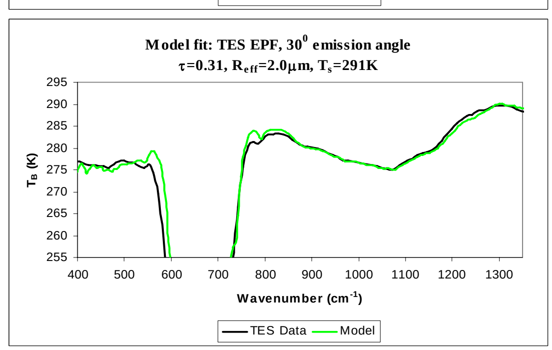
First we initialize the model with a choice of parameters q_0. We then construct a model spectrum $T_{B,model,\nu}$ and compare it to the data $T_{B,data,\nu}$. Having constructed the sensitivity matrix we can solve for the parameters in the data q_{data}.

This project retrieves dust optical depth, effective radius, and surface temperature, using model fits to the data at three wavenumbers. The model is initialized using TES-team derived values [1] for dust optical depth and surface temperature, and a typical effective radius [3] of 1.7μm.

Results: The method can efficiently retrieve dust optical depth, effective radius, and surface temperature from MGS TES data. There is an ambiguity to the dust optical depth results, because variation of optical depth has a similar effect on the spectrum as variation in dust vertical distribution. We need an independent way to untangle this ambiguity. For example, global circulation models [4,5,6] simulate dust vertical mixing and may be useful to constrain data retrievals.

We've tested the model for various conditions and viewing geometries. In particular we examined model fits to an MGS overflight with emission phase function (EPF) observation sequence in conjunction with Mini-TES observations at the Mars Exploration Rover Opportunity landing site (orbit 23763; sol 22). Figure 1 a-d show the model fits, as well as the retrieved parameters. The EPF sequence retrievals are consistent with one-another, but the Opportunity skyward-looking observations (Mini-TES) result in significantly lower particle size. We believe that this inconsistency in retrieved particle size is due to incorrect optical properties for the dust, but it could also reflect non-uniform vertical mixing. We are exploring these possibilities at the moment.





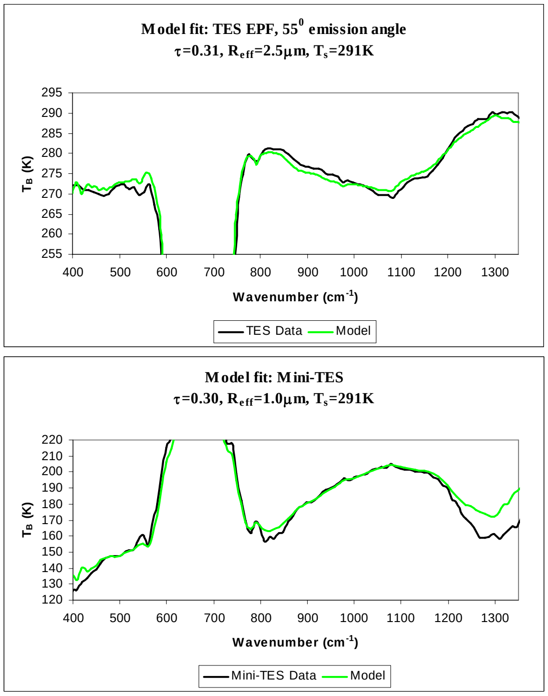


Figure 1 a-d. Model fit to TES EPF observation and Mini-TES skyward-looking observations during MGS' overflight of the Opportunity landing site (orbit 23763).

The retrieval algorithm can be used for larger, global data sets, efficiently retrieving selected parameters. These results can be used to study spatial and temporal trends of dust optical depth, particle size, as well as surface temperature, and to compare these trends to those predicted by global circulation models [4,5,6].

References: [1] Smith M. D. et al (2000) *JGR*, *105 (E4)*, 9589. [2] Smith M. D. et al (2001) *GRL*, *28*, *4263-4266*. [3] Wolff, M.J., Clancy R.T. (2003) *JGR*, *108 (E9) 5097*. [4] Haberle R. M. et al (1982) *Icarus*, *50*, *322-367*. [5] Murphy J. R. et al (1990) *JGR*, *95*, *14629-14648*. [6] Murphy J. R. (1995) *JGR*, *100*, *26357-26376*. [7] Stamnes K. et al (1988) *Applied Optics*, *27*, *2502-2509*.