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Relation between albedo changes and dust redeposition on Syrtis Major region of Mars

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Abstract. Syrtis Major is a near equatorial dark region of Mars and its composition is known to be basaltic. It is also known that it is a region undergoing high albedo variations. In this study we analyzed MGS TES ancillary data (i.e. surface albedo, thermal inertia and atmospheric dust opacity) in order to relate these variations to different surface conditions. Looking at these data (spanning two separated biennia - i.e. 1999-2000 and 2003-2004) we noticed that dust opacity raises with albedo, but thermal inertia does not decrease with albedo, as expected if albedo variations was due to dust redeposition. So we found out that TES albedo is not the pure surface albedo, but it is linearly related with dust opacity.

Key words. Mars – TES – Albedo – Syrtis Major – Thermal Inertia – Dust opacity

1. Introduction

Several authors focussed their works on Syrtis Major, a nearly equatorial dark region of Mars, and so its composition is well know (Bandfield et al. 2000).
One of the main characteristics of this region is its high albedo variation, probably due to the effect of dust redeposition.
In particular Mustard and Cooper (Mustard and Cooper 2005) compared data from Phobos-2 ISM and Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES), two different instruments that orbited Mars in different epochs.
Their attention was focussed primarily on the albedo features and so they found out that over all the regions examined both by TES and ISM the ratio between their respectively albedo is about 0.78. This value of the ratio is nearly constant over all the regions, apart from Syrtis Major, where they found a value of about 0.8 for Eastern Syrtis Major and 1.15 for Western Syrtis Major.
They imputed the non unity value of the ratio to the different way to compute albedo between ISM and TES and tried to link the difference in albedo in Syrtis Major to difference in soil composition.
They found a slightly different VIS/NIR spectrum in West Syrtis Major respect to Eastern Syrtis, but this difference is not reproduced in the TIR spectrum and so they did not find a plausible reason for the albedo changing.
The present work is devoted to finding an answer to their question and to do so we analyzed ancillary TES data, such as albedo, thermal inertia and atmospheric dust opacity.

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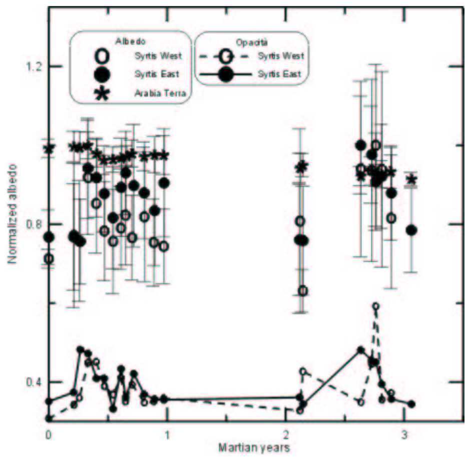

Fig. 1. Comparison between normalized albedos from Arabia Terra, Western and Eastern Syrtis Major. The normalized albedo is computed by ratioing all the albedo from a region by the maximum albedo of that region (the bars represent the standard deviation of the measured mean). At the bottom of the figure are plotted the atmospheric dust opacities for Eastern and Western Syrtis (not on the same axis of albedos): it is clear the dependence of the TES albedos by dust opacity.

2. Data analysis

First of all we want to point out that the analysis performed by Mustard and Cooper was not perfectly coherent, because they used different types of albedo for their study. In particular they used a "single observation" albedo for the ISM value and an albedo averaged over 5 years for the TES value.

For a region such as Syrtis Major this would certainly lead to a mistake and, to prove this, we extracted TES albedo collected both on Western and Eastern Syrtis Major, at constant intervals of 30 degrees of solar longitude (LS)

Taking a mean of all the data we obtained values of albedo very similar for the two subregions (0.12 for Eastern Syrtis and 0.11 for Western).

Furthermore it is clearly visible in Figure 1 that the albedo variation on Syrtis Major is up to 60 percent, ranging from about 0.1 to 0.15, and the two ISM values are recorded both on Western and Eastern Syrtis.

After doing this analysis we continued to study the region by using thermal inertia and atmospheric dust opacity collected over three different zones of Syrtis (Fig. 2), because these parameters are thought to be indexes of dust both on the surface and in the atmosphere.

Contrarily to what it would be expected if the albedo variations were due to different abundances of fines on the surface, thermal inertia does not decrease as albedo increases.

Because the TES thermal inertia is computed using both TES night-time surface temperatures and TES albedo (Christensen et al. 2001) we passed to analyze the latter, by means of synthetic spectra.

The result is that as dust opacity increases the albedo measured by TES changes, accordingly to the formula:

$$A(\tau) = A_0 + \alpha(A_0) * \tau$$

where, A is the albedo, A_0 is the surface albedo and α is a term dependent by the surface albedo and takes in account backscattering, indirect illumination and extinction (Erard et al. 1994).

As it is clear in Figure 3 the data are in good agreement with this theory and so TES albedo is not a measure of surface albedo only. This would obviously affect the thermal inertia measurement and so it is clear that this parameter is not good to characterize the quantity of fines deposited on the surface.

3. Conclusions

This study, though preliminary, permitted us to found an answer to the Mustard and Cooper's question: the albedo and spectral differences between ISM and TES observations were not due to mineralogical differences, but to the different method used with the two instruments.

Furthermore we found out that TES thermal inertia is not a good parameter for the surface characterization and that the only way to study albedo variations with TES ancillary data is to use the formula (1) to retrieve the A_0 value.

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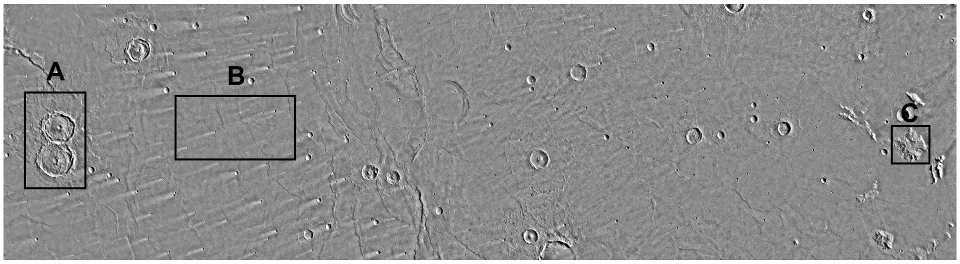

Fig. 2. Map of Syrtis Major, showing the three region selected for the analysis. The upper-left corner coordinates are 9 N, 300 W; the lower-right corner coordinates are 4 N, 280 W.

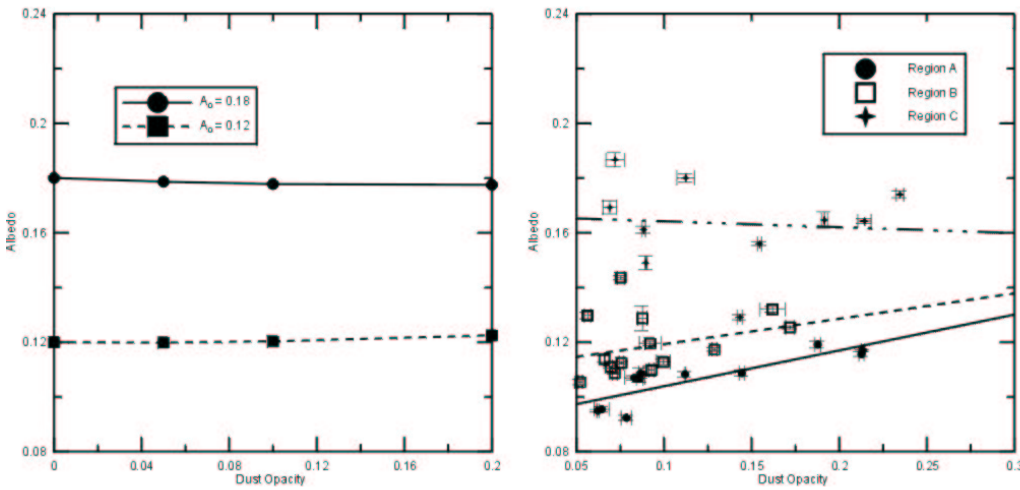

Fig. 3. On the left: a plot showing the dust opacity vs albedo trend for synthetic spectra. On the right: the same plot with real data. The agreement seems good.

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