THREE CONSECUTIVE YEARS SEASONAL CAP RETREAT OBSERVATIONS IN THEMIS INVESTIGATION. A. B. Ivanov, *Planetary Science Institute, 1700 E. Ft. Lowell, Suite 106, Tucson, AZ, 85719,e-mail : anton@psi.edu*, THEMIS Science Team.

1 Introduction

The CO_2 ice caps on Mars advance and retreat with the seasons. This phenomenon was first observed by Cassini and then confirmed by numerous ground based observations in 19th and 20th centuries [1]. With the advent of the space age observations of the seasonal ice cap were done by all orbiting spacecraft starting with Mariner 7. Viking Orbiters, Mars Global Surveyor (particularly Mars Orbiter Camera (MOC [2]) and Thermal Emission Spectrometer (TES [3]) instruments) have accumulated significant data on the retreat of the CO_2 seasonal cap. Mars Odyssey spacecraft and the THEMIS instrument have been operational since 2001. Additionally, Mars Express and Mars Reconnaissance Orbiter (MRO) spacecraft became operational after Mars Odyssey and started to return data. There is now a tremendous amount of data, concerning polar areas of Mars. For our project, Mars Express OMEGA data and MRO's CRISM, CTX and MCS data are of particular importance. OMEGA ([4, 5] and CRISM [6] instruments allow very interesting insights into process of of CO_2 sublimation properties of various phases of ice. MCS [7] data can be used to cross-calibrate THEMIS data.

The major goal for this work was to initiate an inter-annual program for observations of the seasonal ice caps retreat using the THEMIS instrument.Currently we have data from 3 consecutive Martian years in the THEMIS program. Starting Mars year 27 (to use same notation as in [2]), we have planned an observational campaign in which the THEMIS instrument (onboard the Mars Odyssey spacecraft) repeatedly observed the north seasonal polar cap from mid-winter to late spring. THEMIS allows simultaneous observations in both Thermal IR (12.57μm) and Visible wavelengths (0.65μm). Mars Year 27 corresponds to second Martian year of THEMIS operations.

We will present an algorithm that relies on fully calibrated data. We have validated [8] our method against a model [3] constructed from the MGS TES data from the same season and have proven that this method provides reliable estimates of the seasonal ice cap boundary. Here we will present extension of our analysis to 3 years of observations, including the South Polar ice cap.

2 Available data

In this study, we have used data from the Thermal Emission Imaging System (THEMIS) instrument ([9]) onboard the Mars Odyssey spacecraft. The IR camera has 10 filters from 6 to 15 μm ([9]) and images the surface with 100m/pixel resolution.

We have implemented a specific campaign which was designed to track the edge of the northern seasonal ice cap. Each image was targeted approximately near the cap edge and had to satisfy other requirements such as conflicts with other simultaneous campaigns. All images were then screened for Latitude Temperature Profile (LTP) method (see below), based on the fully calibrated data available on the ground, to have a minimum brightness temperature less then 175K (to ensure that ice

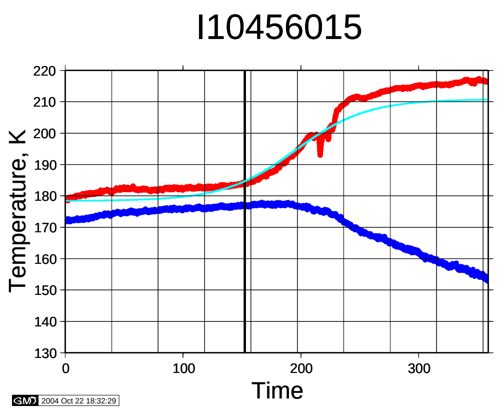

Figure 1: THEMIS IR (image id 10456015) data for images that include the polar cap edge. Band 9 - red, band 10 - blue. The figure shows temperature (averaged in the sample direction) vs. line number, from north to south. The thick line is the fit of the function (Section 3), and the thin vertical line is where the LTP method has identified the cap edge.

is present) and a maximum temperature greater than 185K (to ensure that some defrosted terrain is present).

Mars year	North Pole	South Pole
MY 26	5	53
MY 27	107	36
MY 28	36	35

Table 1: Number of images available for analysis of ice cap retreat in respective hemispheres. Number of images corresponds to the number of points that can be used to plot Figure 2

Table 1 summarizes our current observations. We have identified 113 such images from more than 450 total images collected in the North Polar region during the THEMIS primary mission [8] (MY 26 and 27). This set of images was used for our model validation vs. TES model [3]. There are less images for other years because we have used manual selection for data validation. For other years and the South Polar region we have employed an automated algorithm for data selection, but it is more conservative than what we have used for data validation exercise. Figure 1 illustrates one of the images that we obtained during primary mission campaign. The plot shows mean temperature in the sample direction for each line in the image. Moving from left to right on the plot generally corresponds to moving from north to south in an image. We have superimposed the sigmoidal fit (see Section 3 for details) to the data, and the cap edge thereby identified is indicated by a vertical line.

3 Data Analysis and Discussion

The edge of the seasonal ice cap is not a step function at the THEMIS scale (100m/pixel). This resolution allows us to observe the defrosting region with high precision. In this work, we define the edge of the ice cap where 50% of the surface is covered with frost. Here we note, that there are plenty of of processes, related to ice sublimation and phase changes. Data from CRISM [6]and OMEGA [4, 5] data will provide understanding of the processes that define THEMIS temperature profiles.

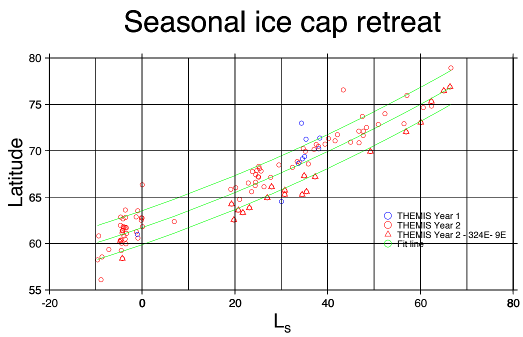

Figure 2: Retreat of the seasonal CO_2 ice cap as observed by the THEMIS instrument. This graph shows data from two years of observations. Year 1 data is shown by the blue circles; Year 2 data is shown by red circles and triangles. Red triangles denote CO_2 cap edge detections that lie in the longitude range from 324E to 8.5E. The green line shows a 3rd-degree fit to the data with bounding confidence interval. Absence of images containing the cap edge between $L_s 0^\circ$ and 20° produced a gap in the observations.

To find the cap edge boundary, we fit a sigmoidal function to a temperature profile (see Fig. 1). Sigmoidal function is very similar to the arctangent function, but easier to work with. Whenever this function crosses a predetermined value, which corresponds to approximately 50% ice content on surface, we store the x-value of the corresponding image line. This value is then converted to latitude, longitude and L_s. Method, described above, is referred to as Latitude Temperature Profile (LTP).

The next step, after algorithm validation is put observations made by THEMIS IR into context of observations made in previous years. All authors use slightly different approaches. Here we propose to use a simple method where the ice cap regression is approximated by a simple linear relation $L = a \times L_s + b$, where L - is latitude of the edge of the ice at time L_s. Consequently, a - is the rate of recession and b is an offset or position of the cap at $L_s = 0$. In [8] we compared observations made by MGS TES instrument and THEMIS year 2 observations. Here we also note that MOC Visible (as well as CTX) observations also exist [2], but were not taken into account due to differences in definitions of the ice cap boundary. Visible observations tend to favor observations of the white ice cap, where CO_2 is is indistinguishable from water ice.

4 Summary

The main goal of this work is to establish a long term campaign to perform systematic observations of the retreat of Mars seasonal ice caps. The THEMIS instrument has collected data over the 3 Martian winters in both North and South Pole. Initial results have been presented in [8] and were validated against TES model. One of the problems that were identified in [8], were intermittent processes that were taking place as CO_2 ice was sublimating. Fortunately, it is now possible to address these issues using OMEGA and CRISM data taken in these regions. We will present our latest retreat curves for 3 years of observations for both North and South polar regions and compare it with other available historic data.

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