Effect of Albedo Change on Martian Temperature

Upper Darby High School, Period 5

Introduction:

Similar to Earth, Mars is experiencing a period of global warming. However, the causes for global warming on Mars may differ from the causes of global warming on Earth. Our hypothesis is Martian winds are causing lighter dust on the surface to be blown away which is exposing the darker surface under the dust of Mars. This darker surface absorbs more heat from the Sun, and may be the cause of global warming. Specifically, we want to determine if areas of Mars that are becoming darker are causing the local temperature for that area to increase. This research is important because understanding global warming on Mars will help us to understand global warming on Earth.

Background:

Based on a study by Lori Fenton, darkened surfaces heat up when Martian winds and dust devils blow the sand and dust away. This exposes the darker surface underneath and attracts heat, which in turn warms Mars' surface.

Dust devils are formed when hot air above the surface rises through a small pocket of cooler air above it (Figure 1). When conditions are right, the air starts to rotate and stretch vertically. The mass moves closer to the axis of rotation, intensifying its spinning motion (Figure 2). As a result of the incoming hot air, it becomes self-sustaining.

The tracks of a dust devil (Figure 3) are darker than the surrounding surface.

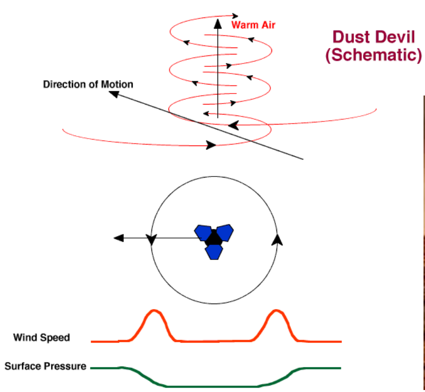


Figure 1: The formation of a dust devil

Figure 2: A dust devil

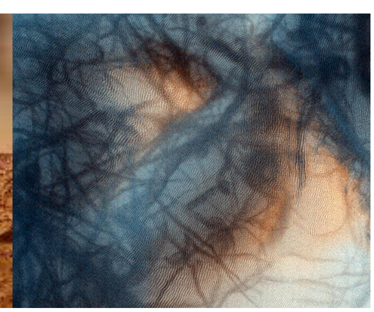
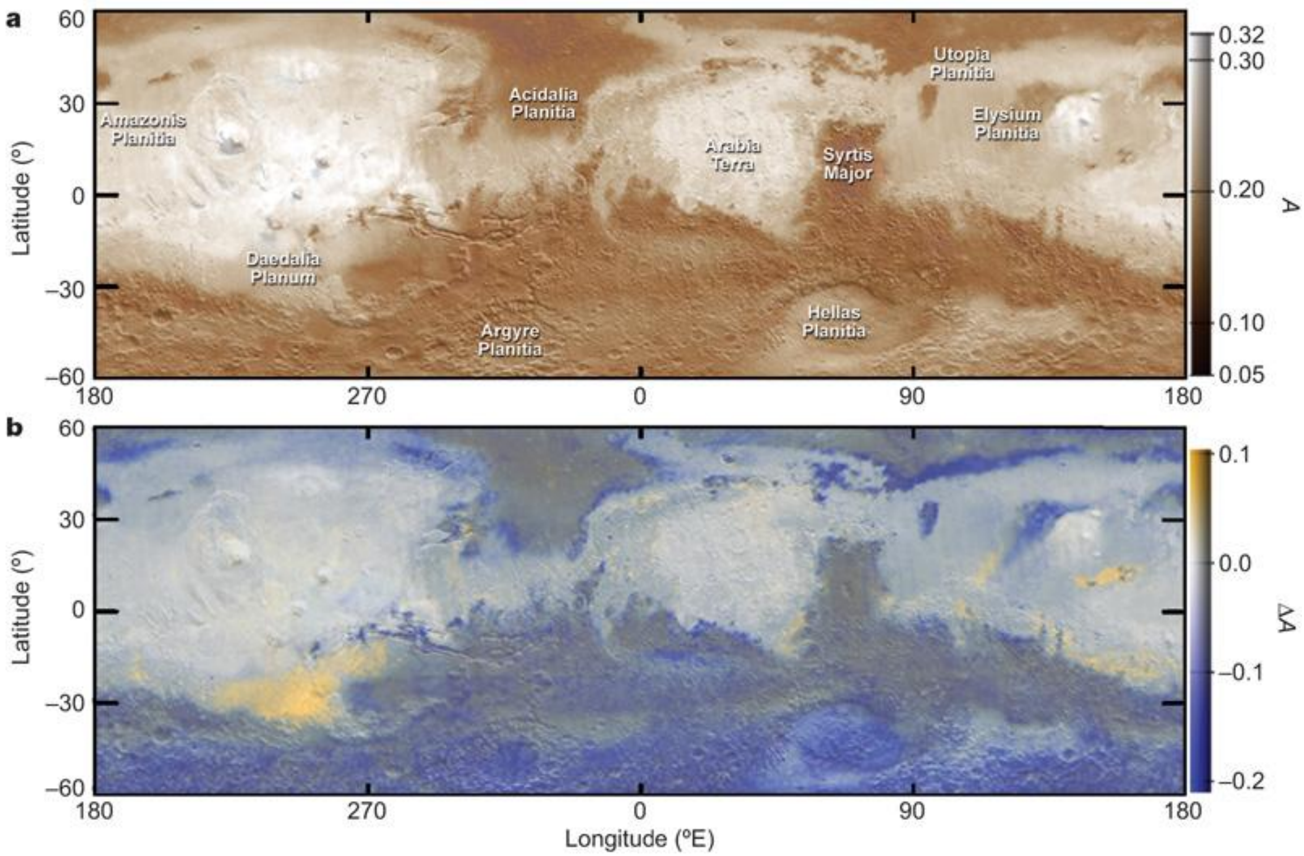


Figure 3: Dust devil tracks

- http://mars.jpl.nasa.gov/MPF/science/atmospheric.html **(schematic)**
- http://news.nationalgeographic.com/news/2011/05/pictures/110523-space-pictures-hubble-shuttle-plane-launch-mars-dust-devils-145/ (dust devil tracks)
- http://science.nasa.gov/science-news/science-at-nasa/2005/14jul_dustdevils/ **(dust devil)**

The reflecting power of a surface is called albedo. Fenton created the following map which shows the areas with increasing and decreasing albedo values on Mars from the 1970s to the year 2000. According the Fenton, this decrease in albedo has caused the temperature on Mars to increase by 0.65° in the past 30 years.



(http://www.nature.com/nature/journal/v446/n7136/fig_tab/nature05718_F1.html)

The albedo on Earth is decreasing around populated areas as well due to dark mixtures such as tar and asphalt being used frequently. While most scientists agree that greenhouse gases cause global warming on Earth, the decrease in albedo levels on Earth may also contribute to global warming on Earth.

Methods

We collected data for the following six locations on Mars.

33E, 30
98E, 30
135E, 30
80E, -30
153E, 30
255E, -30

We chose all data points on either 30° or -30° latitude because they would all experience the same level of sunlight during their respective summer, which includes solar longitudes between 75˚ and 105˚ for 30˚ latitude and 255˚ and 285˚ for -30˚ latitude. We chose these six locations specifically because they have differing albedo levels according to Lori Fenton's albedo map made with data between the years 1970 to 2000.

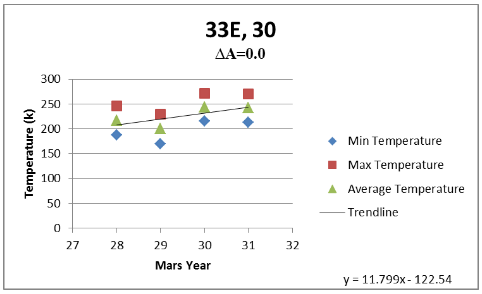
We used JMARS to access THEMIS IR stamps taken from 12-18 local time, and recorded minimum and maximum surface temperature during the summer for Mars years 26 through 30. We had hoped to measure the albedo value for each stamp, but that data was not available. We also took the change in albedo from Fenton's map with yellow representing areas with increasing albedo, white representing areas with a consistent albedo, and blue representing areas with a decreasing albedo.

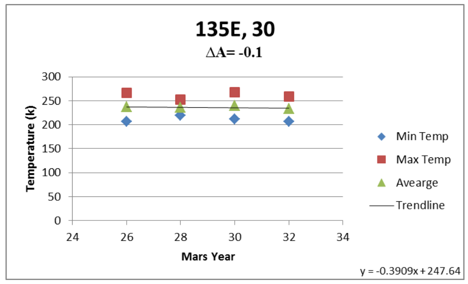
Data

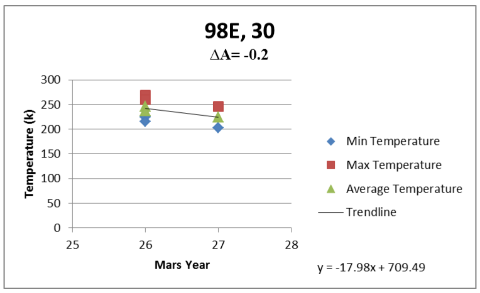
We collected twenty-one THEMIS images. Unfortunately, we could not find any stamps from 12-18 Local Time for point 153E, 30. That point has been left off of our chart.

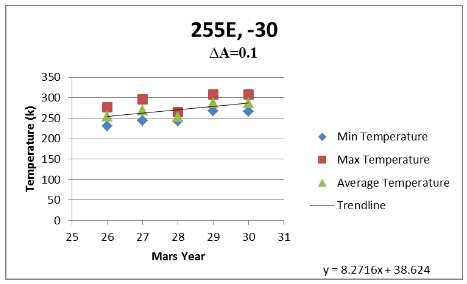
LON/LAT	Image ID	Lcl Time	Solar Long	Yr	Min Temp (K)	Max Temp (K)	Avg Temp (K)	Albedo Chg
255E,-30	I08040001	16.658	274.9755	26	231.277	276.692	253.984	0.1
255E,-30	I16430002	16.541	277.2983	27	243.292	296.394	269.843	0.1
255E,-30	I24704003	16.796	273.7153	28	241.825	264.663	253.244	0.1
255E,-30	I33188002	15.185	280.989	29	267.03	308.206	287.618	0.1
255E, -30	I4154900	15.302	284.424	30	265.683	307.227	286.455	0.1
33E, 30	I20855007	17.517	98.535	28	187.598	246.641	217.119	0
33E, 30	I29241011	17.755	100.126	29	169.32	229.969	199.644	0
33E, 30	I4576011	16.235	76.44702	31	212.842	270.763	241.802	0
33E, 30	I37089020	16.178	82.10873	30	215.689	271.485	243.587	0
80E, -30	I07700003	16.838	257.3088	26	239.845	274.197	257.021	-0.1
80E, -30	I08087005	16.531	277.379	26	245.521	291.182	268.351	-0.1
80E, -30	I07725003	16.814	258.614	26	245.822	277.643	261.732	-0.1
80E, -30	I6174002	16.81	264.053	27	244.756	280.654	262.705	-0.1
80E, -30	I24423005	17.04	259.127	28	245.875	276.182	261.028	-0.1
135E, 30	I37117003	16.665	77.191	26	206.824	266.812	236.818	-0.1
135E, 30	I20552044	17.435	82.5	28	219.866	252.013	235.939	-0.1
135E, 30	I37589020	16.151	100.321	30	211.466	267.257	239.361	-0.1
135E, 30	I45252015	16.128	75.586	32	207.131	259.011	233.071	-0.1
98E, 30	I02306005	15.963	30.85163	26	223.847	269.143	246.495	-0.2
98E, 30	I04865005	17.181	124.9223	26	215.045	260.05	237.547	-0.2
98E, 30	I1034505	16.656	10.15832	27	202.558	245.525	224.041	-0.2

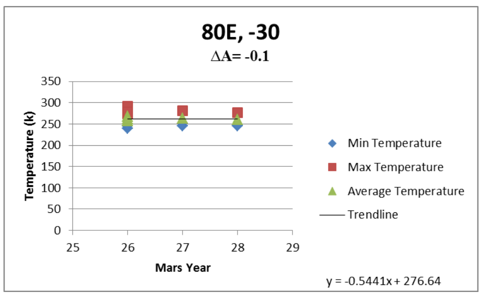
Average Temperature vs Mars Year





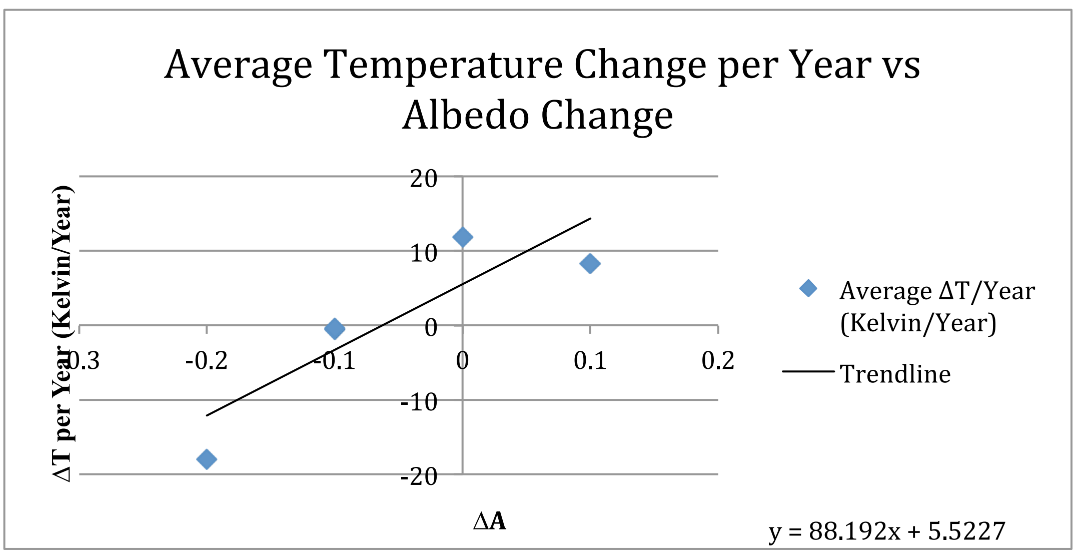




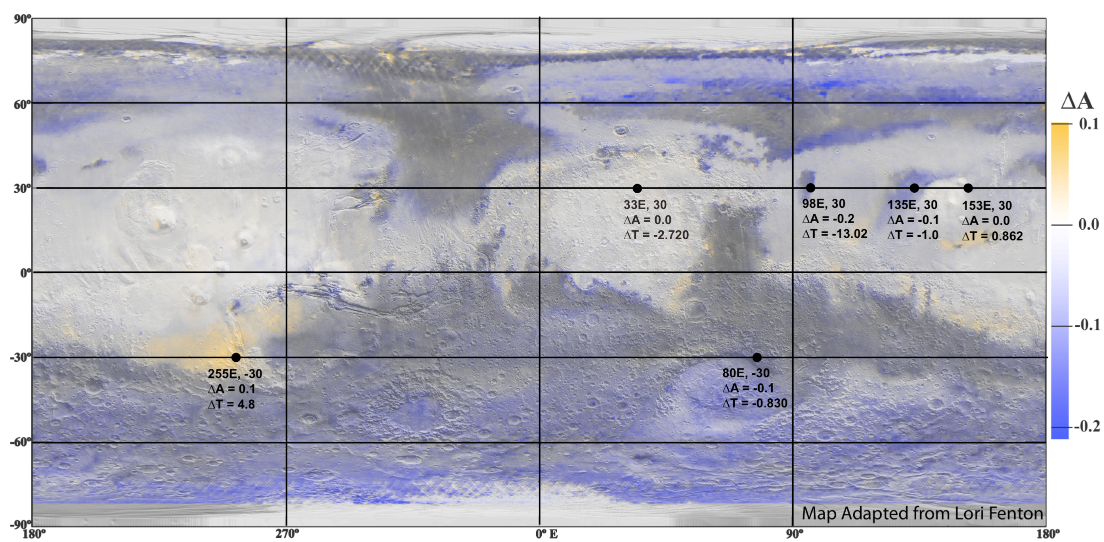


Using the slopes of the best-fit lines from the Average Temperature vs Year graphs on the previous page, we found the Average Temperature Change Per Year and plotted vs Albedo Change.

Δ Albedo	Average ΔT/Year (Kelvin/Year)
0.1	8.2716
0	11.799
-0.1	-0.5441
-0.1	-0.3909
-0.2	-17.98



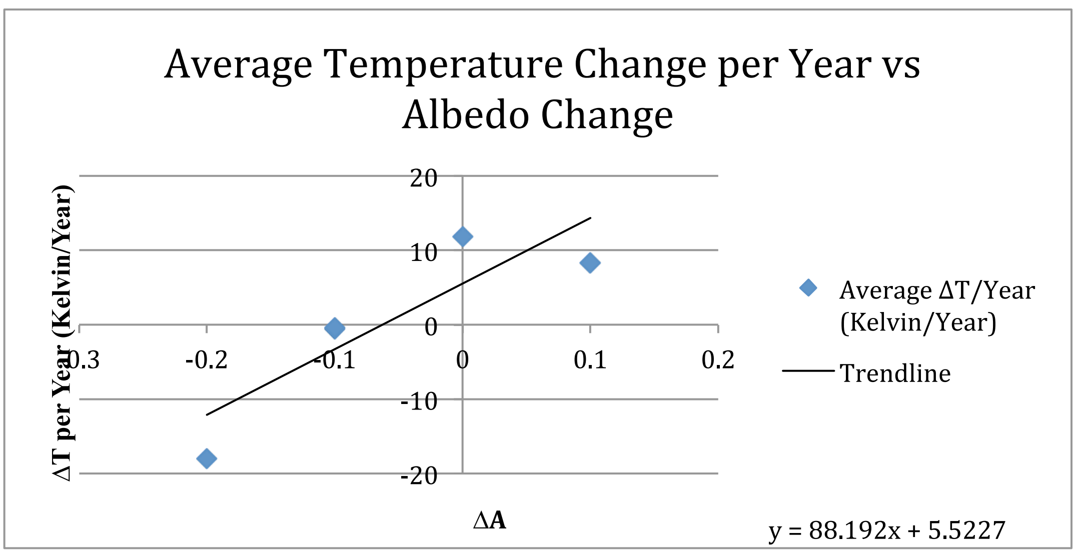
Mars Albedo & Temperature Data



"Lori Fenton collected data using an albedo map from the 1970s produced by an infrared thermal mapper onboard NASA's Viking probe and a more recent map from 1999-2000 taken by a sensor aboard the Mars Global Surveyor probe. Surface air temperatures increased by 0.65 degrees C over a 20-year period, the authors said." (Canadian Content)

Discussion

Δ Albedo	Average ΔT/Year (Kelvin/Year)
0.1	8.2716
0	11.799
-0.1	-0.5441
-0.1	-0.3909
-0.2	-17.98



Our data shows that as albedo increases temperature also increases. Our hypothesis was that temperature would increase as the Albedo levels decreased. We inferred that as the surface got darker, the temperature would go up because the surface is absorbing more of the sun's heat. The data we collected did not support our hypothesis.

There could be inaccuracies in our experiment. Any data gathered at inconsistent times or solar longitudes may affect our data. We also chose specific points for collecting our data. It's possible that only focusing on these points, and not Mars as whole, will give us an inaccurate conclusion.

With a timeline only from 2002-2010, the temperature information collected in those years may not be an accurate representation of the temperature change overall. Similarly, Lori Fenton's map of the change in albedo is made up of data gathered from the 1970's to the 2000's, so its correspondence with our data is only assumed. Moreover, the THEMIS images are large and, within our circumstances, may not have been available at our precise points. Thus giving us data outside of our initial areas.

Misinterpretations could occur in our experiment as well. It could happen that an area we analyzed had circumstances, such as a dust storm, that would affect the readings. To build on that, we only took temperature readings of one day from each year. This, as opposed to having data from multiple images per year and taking an average of those, may not portray accurate results.

Conclusion

The purpose of our research was to determine the effect of albedo change on Martian temperature. From the data we collected we are unable to determine this effect. This is because our data doesn't support our hypothesis and also there is so little data available that is relevant to our research. We also are not certain if all of our data applies to all of Mars.

Our data does not support our original hypothesis, which is that a decrease in albedo leads to an increase in temperature. In contrast, our data showed a decrease in albedo leads to a *decrease* in temperature.

To expand on our research, more THEMIS IR stamps would need to be collected and examined. There could also be more research done on Mars globally, instead of isolated points. More recent albedo readings would also be needed to test our hypothesis. Expanding our research may help to better understand global warming on Earth.

We would like to acknowledge Roseann Burns, our seminar teacher, for helping us. We also acknowledge Lori Fenton for making the albedo map that we used to find our readings. We would also like to acknowledge NASA and the MSIP program for providing the THEMIS stamps.

References

"Dust storms turn up the heat on mars". Jelsoft Enterprises Ltd. 2012. 12-13-12. <http://forums.canadiancontent.net/science-environment/60981-nature-publishes-mars -global-warming.html>.

Wilson, Greg. "Mars Pathfinder Science Results". Nasa. < http://mars.jpl.nasa.gov/MPF/science/atmospheric.html>.

National Geographic Society. 2012. <http://news.nationalgeographic.com/news/2011/05/pictures/110523-space-pic tures-hubble-shuttle-plane-launch-mars-dust-devils-145/> .

Christensen, P.R., N.S. Gorelick, G.L. Mehall, and K.C. Murray, *THEMIS Public Data Releases*, Planetary Data System node, Arizona State University, <http://themis-data.asu.edu>.

Gillette , Brandon, and Hamilton, Cheri. "Earth's reflection: Albedo." . National Science Teachers Association (NSTA), n.d. Web.

Bell, Trudy. "The Devils of Mars." *NASA Science News*. NASA, 14 2005. Web. <http://science.nasa.gov/science-news/science-at nasa/2005/14jul_dustdevils/ >.