Are Observed White Areas on Mars Real?

By: Jeff Beish

Association of Lunar and Planetary Observers (A.L.P.O.)

Introduction

Astronomers describe so-called white areas observed on Mars as bright patches of light most often seen in the desert regions of the Red Planet. They are generally bright in all colors and conspicuous in integrated light (no filters); however, we must analyze this phenomenon before jumping to conclusions. The nature of white areas, as described by the past A.L.P.O. Mars Section Recorder, Chick Capen, should be discussed at length. A brief description paraphrasing Capen is as follows:

'A <u>white area</u> is a most delicate and challenging feat of observation. Detection of atmospheric volatiles at the boundary between the Martian atmosphere and its surface can be seen with aid of color filters. In this volatile regime, ice fogs and frosts, often called bright patches, can be distinguished from elevated clouds by means of comparing their relative brightness and boundary definitions as seen with the aid of blue, blue green, green, and yellow filters. If the suspect bright feature appears brighter in blue light than it does in green or yellow light, it is most likely an atmospheric cloud. If it is brighter and better defined in blue-green light than in blue or yellow light, it is probably ice-fog contiguous to the surface. If the patch appears brighter with sharp boundary in green and yellow light and is not well seen in blue light, it can be identified as surface frost.'

By now, we should know that it is possible to see both the surface and atmosphere of Mars from earth. Mars' thin atmosphere is more difficult to see and requires special observing techniques and equipment. We are hard pressed to detect clear gasses or vapors, such as carbon dioxide (CO_2) and water vapors (H_2O), in Mars' atmosphere; however, we can see them quite readily when they condense or freeze-out. We can also see these vapors in a different form after they deposit onto the surface of Mars.

Principles of Filter Use for Detecting White Areas

Since the observer has to see through the atmosphere of Earth and Mars, one would expect sunlight scattered by aerosols in the atmospheres to be seen differently in each of the visual colors. Several atmospheric conditions and physical effects are modified by the use of color filters at the telescope:

<u>Scattering</u> interposes a luminous veil between the observer and his/her subject. Scientists have shown that for particles in a planet's atmosphere of a given size the scattering is inversely proportional to the fourth power of the wavelength of the light. Hence, violet light of 400 nm is scattered about 16 times more than deep red light of 800 nm; Earth's daytime sky is blue as a result of this property. The Martian atmosphere scatters light in the same manner and thus allows us to observe Martian aerosols at the different relative atmospheric depths.

Atmospheric penetration. To explore an atmosphere similar to Earth's to various depths, molecular scattering can be exploited. Since the shorter wavelengths are scattered more, it follows that ultra violet light scarcely penetrates an atmosphere at all, violet light penetrates to some depth, blue still deeper, while blue-green may reach the solid surface.

Irradiation occurs between adjoining areas of unequal brightness. The amount the bright area appears to encroach upon the fainter one is approximately proportional to their intensity difference. This is evidently a physiological effect, originating within the eye itself. A deep red or orange filter reduces this effect while observing.

How Do White Areas Appear to Us

The diurnal behavior of the boundary-layer and its location also helps to distinguish it from clouds and limb haze. Fogs and frosts form in the chill of the Martian night, rotate with the planet, dissipate in the morning sunlight and usually disappear by local noon. Fogs normally form in valleys, in fossae (linear depressions), basins, and on upper slopes. Frosts are usually noted on cool, light albedo features, plana (plateaus), montes (mountains), and floors of large craters. Because these volatiles are topographically controlled the discovery of their locations and seasonal occurrence is most important to the study of Martian weather patterns and areography.

Ground frosts are tricky and their nature is difficult to determine. When surface frost deposits are seen near the planet's limb sunlight is reflected at an oblique angle, or not directly back to the observer. These deposits will then appear slightly darker than they would if sunlight was directly reflected at the observer. If that same deposit were nearer to the noon hour angle then more sunlight would reflect back and it would appear brighter.

On the other hand, if the area is atmospheric, i.e., an ice-fog or dense particulate matter suspended in the "air," etc., sunlight would be scattered by the particles and would appear brighter -- even if the area were viewed at an oblique angle to the sun. Atmospheric white areas, as in the case of the so-called limb arcs, tend to be spread out over larger areas and thin out near its edges. Therefore, atmospheric white areas will appear to have defused boundaries. Surface white areas tend to have sharper boundaries, as one might expect.

Fog in Earth's atmosphere is composed of water droplets suspended in air. The pressure on Mars is too low to allow water droplets, so we discuss ice-fog in Mars' atmosphere.

After a deposit of a volatile material is exposed to sunlight for a few hours one might also expect sublimation would begin and a haze would form over the deposit. This happens as the white area is rotated away from the morning limb. Therefore, the sun not only begins to reflect more and more light towards the observer it will become more and more scattered and appear to brighten. Common sense? Maybe not.

At the telescope we can prove this by using different colored filters to observe bright patches and record their reactions over a period of a few hours. One expects to see this scenario play out right before their own eyes. As the white area moves away from the morning limb its intensity should increase in blue light and at some point, during late morning hours when the deposit has sublimed away, will decrease intensity in red and green light.

If there are dust particles present then the white area will brighten in red light as well. Many of the limb arcs we see a day or so after a dust storm starts and contains a higher dust component. The appearance of a sudden limb arc may be an indicator of an unreported dust storm in progress. The bright, yellowish red haze over the polar regions is another indicator of possible dust activity somewhere on the globe of Mars.

If the ice crystals form "hoar frost" then they tend to clump up into irregular shaped piles. Small piles of material at low sun angles will cast multiple shadows and the accumulated effect is to darken the surface area. If these frost despots are located near the polar cap then they will appear even darker. Some say this is a result of the so-called contrast effect. It is most likely the result of irradiation in the observer's eye.

Furthermore, if the piles contain less frost material and more ice crystals then some reflection from "glare-ice" platelets may very well brighten the piles and render the areas brighter. Reflected Sunlight will most likely show up in our eyepiece bright in all colors.

Ice or frost can easily form on surface materials. When H_2O or C_O2 vapors reach their respective freezing point then condensation begins onto any near by surface. On Earth the "dew point" defines when dewing occurs. When the temperature equals the dew point then fog and dewing may begin in the air or on a cold surface. This also applies to atmospheric condensates close to the Martian surface, except water droplets will not form at the pressure of Mars' atmosphere. When the temperature of the water vapor floating a few feet above the surface drops below the freezing point and begins to accumulate a condition called ice-fog is possible. Ice-fogs may persist when the winds near the surface will not allow the condensates to fall to the surface. A recent spacecraft landed a roving vehicle on Mars and images from the camera aboard the tiny "car" revealed light surface winds were present down to a few inches in altitude.

We may stop short of calling it snow; however, surface deposits appear as power-like snow drifts as we have seen in Viking Lander images. This is not like the snowflakes or beautifully designed web-like crystals as it is often portrayed. This type of "snow" forms as irregular shaped crystals that are similar in shape to beach sand or platelets. A snowstorm on Mars is not likely to look like snowflakes falling from some cloud but would just suddenly appear on the surface in the early morning sunlight.

At any rate, these white areas are well worth study and close attention by observers to color and color filters reactions are important in this study. The views of Mars though a telescope can be intriguing, but the small disk of the planet makes it a difficult object to study. It is also a bright planet.

Those who photograph the planets are well aware that the intrinsic intensity of the surface of Mars is brighter than any other planet. Exposure calculations require a higher albedo coefficient in the equations for Mars. While Venus or Jupiter may appear brighter to the observer, it is Mars that reflect more sunlight per square meter than the other planets. Venus is apparently brighter due to the closeness and bright albedo of its clouds. Jupiter is just larger and reflects back to us a larger area of reflected light. The human eye utilizing color filters can also detect this difference.