

## Introduction

The Viking Orbiters determined that the surface of Mars' northern residual cap consists of water ice. Observed atmospheric water vapor abundances in the equatorial regions have been related to seasonal exchange between reservoirs such as the polar caps, the regolith, e.g. [1] and between different phases in the atmosphere, e.g. [2]. Kahn [1990] modeled the physical characteristics of ice hazes seen in Viking Orbiter imaging limb data, hypothesizing that ice hazes provide a method for scavenging water vapor from the atmosphere and accumulating it into ice particles. Given that [1] found that these particles had sizes such that fallout times were of order one Martian sol, these water-ice hazes provided a method for returning more water to the regolith than that provided by adsorption alone. These hazes could also explain the rapid hemispheric decrease in atmospheric water in late northern summer as well as the increase during the following early spring. A similar comparison of water vapor abundance versus polar cap brightness has been done for the north polar region [3,4]. They have shown that water vapor decreases steadily between  $L_s = 100-150^\circ$  while polar cap albedo increases during the same time frame. As a result, they suggested that late summer water-ice deposition onto the ice cap may be the cause of the cap brightening. This deposition could be due to adsorption or snowfall. Thus, an examination of north polar water-ice clouds could lend insight into the fate of the water vapor during this time period.

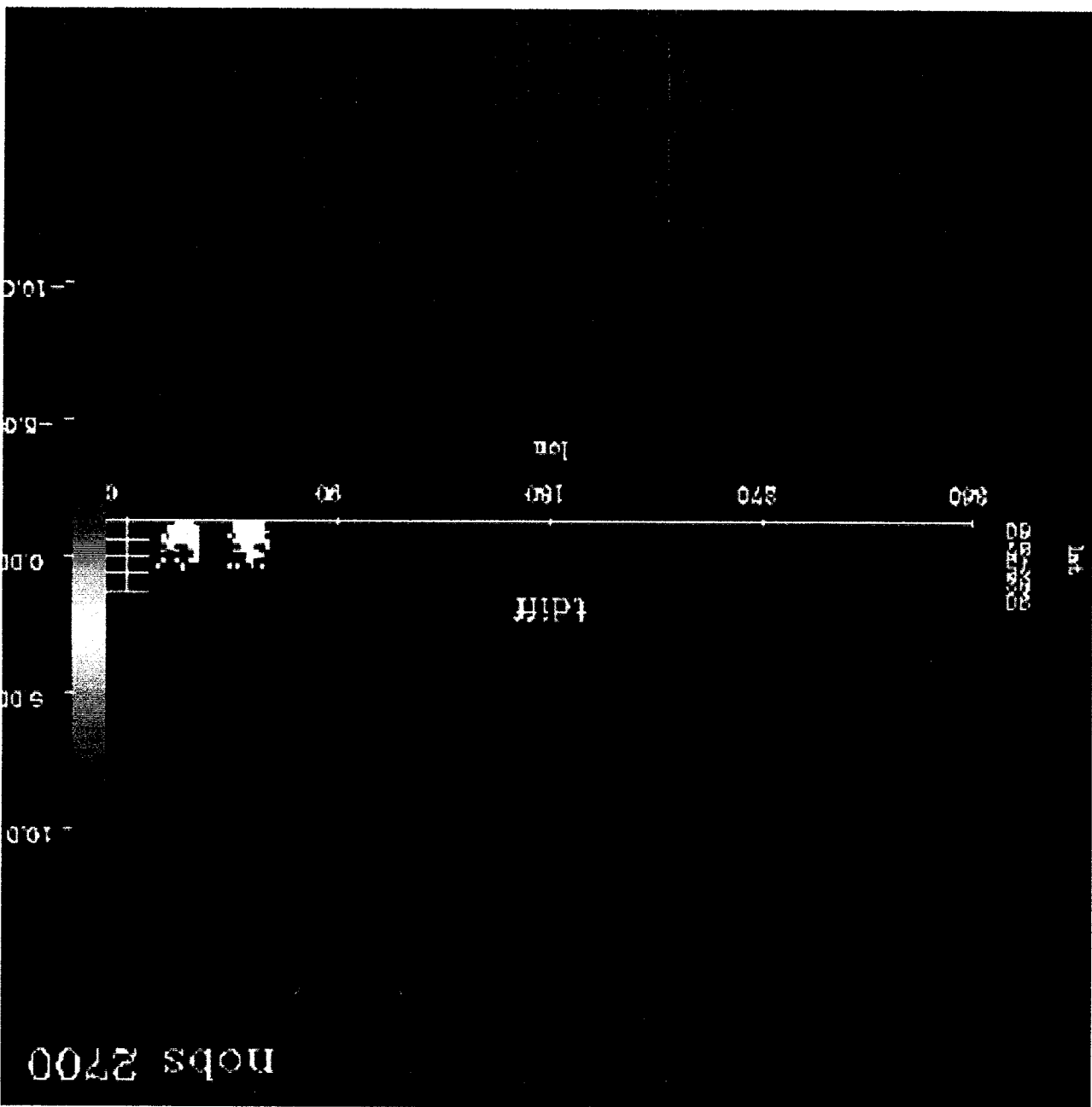
## Method

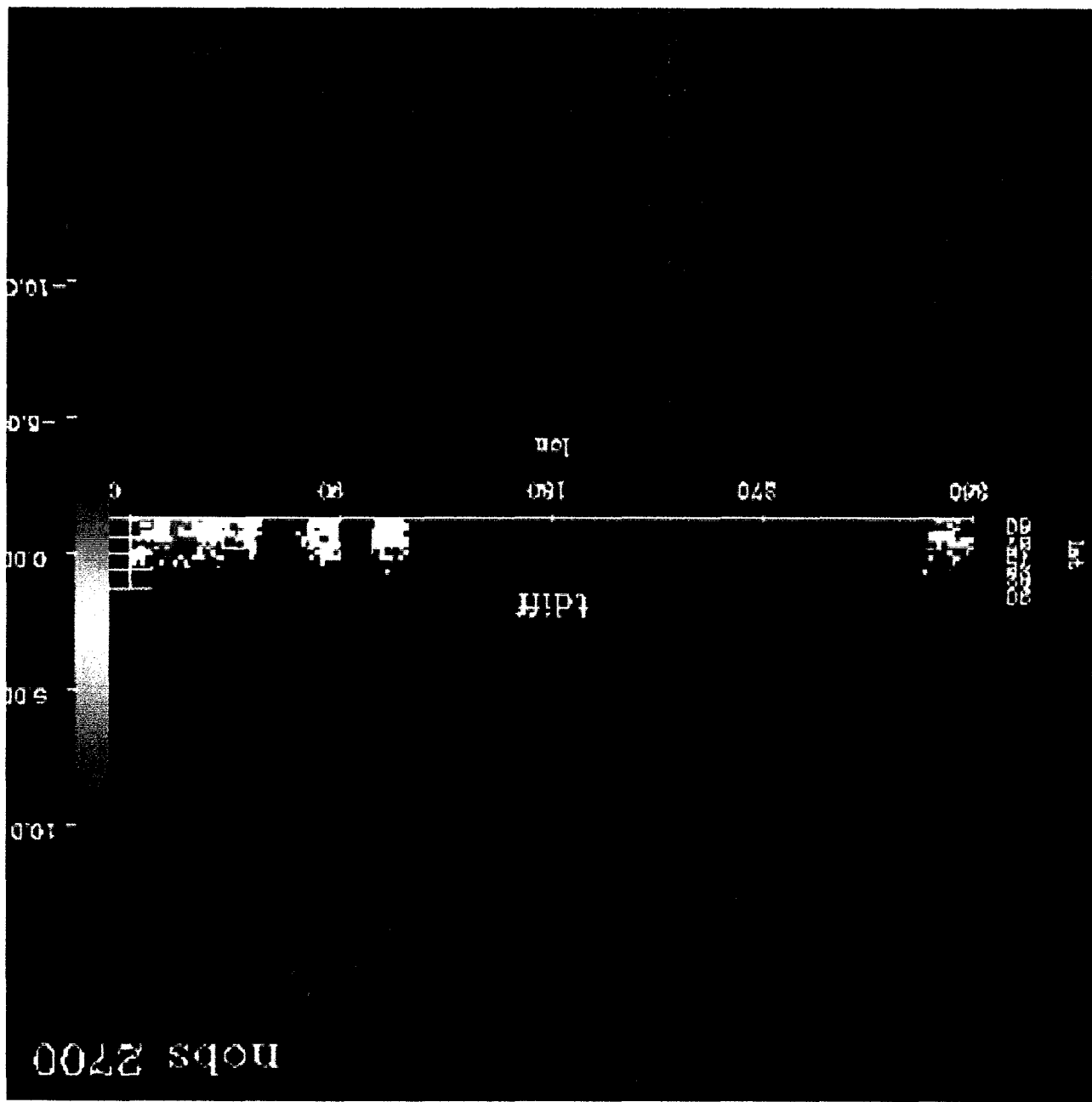
Detection of water ice clouds in the polar regions using visible images has been difficult due to the inherent difficulties of distinguishing bright atmospheric condensates from surface ice features. In addition, water-ice hazes are typically thin and cannot, with visible data alone, be positively distinguished from dust hazes in the atmosphere, e.g., [5]. However, Tamppari et al. [2000] established a technique for detecting water ice clouds on Mars equatorward of  $60^\circ$  latitude [6]. This technique utilized the Viking Infrared Thermal Mapper (IRTM) data set and involved comparing brightness temperatures of the same surface location taken in both the 11 and 20  $\mu\text{m}$  filter. In principle, this technique can be used with any thermal data set in which one channel senses the 11  $\mu\text{m}$  water-ice absorption and the other does not. Essentially, during the daytime when the surface is warmer than the atmosphere, the brightness temperature in the 11  $\mu\text{m}$  channel is reduced compared to the 20  $\mu\text{m}$  channel when a water-ice cloud is present. This is due to the water-ice cloud absorbing surface radiation and re-radiating it at a lower temperature. This technique also depends upon properly modelling the brightness temperature of the surface, given spectrally dependent, non-unit surface emissivities [7].

In the north polar region of Mars over the regolith area surrounding the polar cap, this technique can be applied analogously as in the equatorial region [6], see Figure 2. However, over the polar cap itself, the signature would likely reverse, giving a warmer brightness temperature when a cloud is present by comparison to the very cold CO<sub>2</sub> cap temperature. In addition, the surface emissivities over the polar cap may be very different than over the soil.

## Figures 1 and 2

Shown here, in color, are water-ice clouds in the north polar cap region for  $L_s = 103.26-105.52^\circ$  (figure 1) and  $L_s = 105.52-107.79^\circ$  (figure 2). West longitude is shown along the x-axis and latitude from  $60-90^\circ\text{N}$  is shown along the y-axis. Black indicates no data were present and white indicates where data were present, but no water-ice clouds were present. The cloud signature is shown in blues according to the temperature scale on the right. This signature is the result of differencing the  $11$  and  $20\ \mu\text{m}$  channel data after removing the surface spectral emissivity surface [6]. Darker blues imply a thicker or a colder water-ice cloud.





## **Conclusions**

- Using the methodology of [6], it appears to be possible to determine water-ice clouds over the north polar region of Mars.

## **Future work**

- Update the surface emissivities if better data exist from MGS
- Assess the temperature structure over the north polar region
  - temperature inversions could confuse signal
  - choose appropriate daytime data for analysis
- Assess the cap/regolith boundary for cold surface patches and update methodology if needed (colder surface than atmosphere reverses signature)
- Compare surface thermal model to measured surface temperatures

## References

- [1]Jakosky B. (1983) JGR, 90, 1151-1154. [2]Kahn R. (1990) J. Geophys. Res., 95(B9), 14677-14693. [3]Bass D. S. et. al. (2000) Icarus, 144, 382-396. [4] Bass D. S. and D. A. Paige (2000) Icarus, 144, 397-409. [2]Kahn R. (1984) J. Geophys. Res., 89(A8), 6671-6688. [6] Tamppari L. K. et. al. (2000) ) J. Geophys. Res., 105(E2), 4087-4107. [7] Christensen P. R. (1998) J. Geophys. Res., 103(E1), 1733-1746. [8] Bass D. S. and L. K. Tamppari (2000), 2nd International Conference on Mars Polar Science and Exploration, Aug. 21-25.