

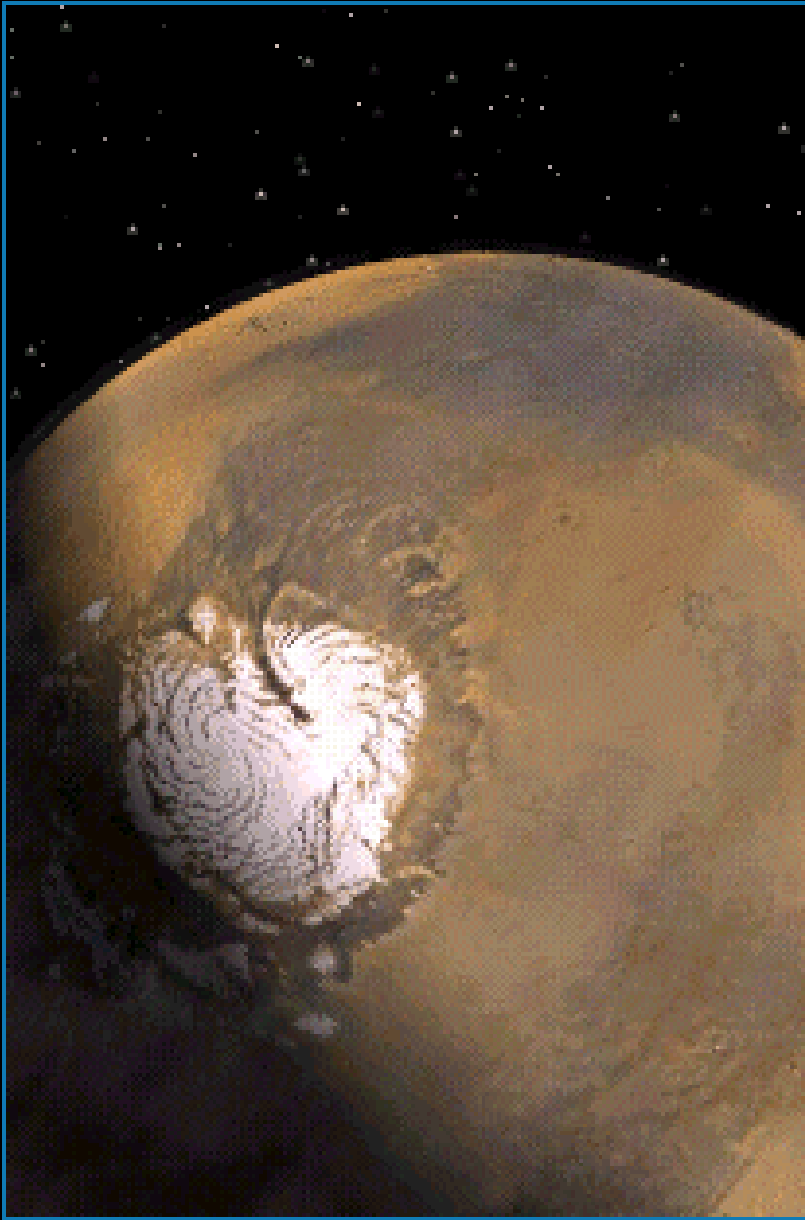
# ***Water on Mars***



## **Remote Sensing Ices on Mars**



# The North Arctic of Mars

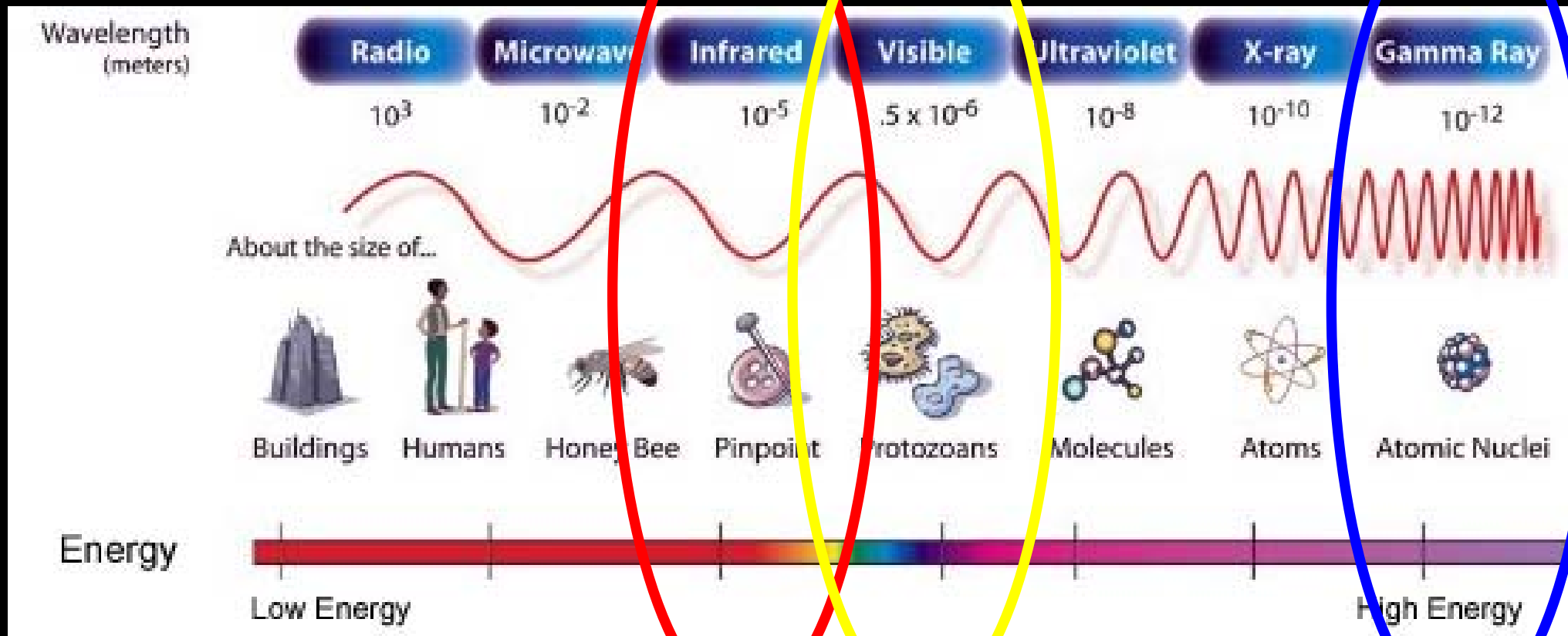


- The white region does not move around from day to day.
- The white region increases in size during the winter and decreases in size during the summer.

**What do you think  
the white areas are?  
What might they be  
made of?**



# Types of Light





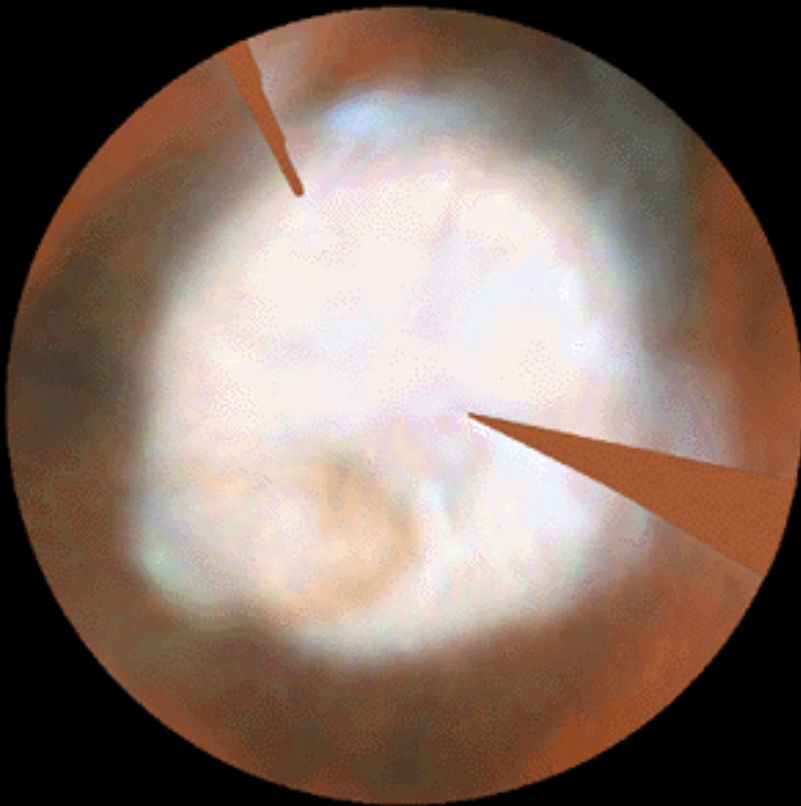
# False color maps of the northern arctic



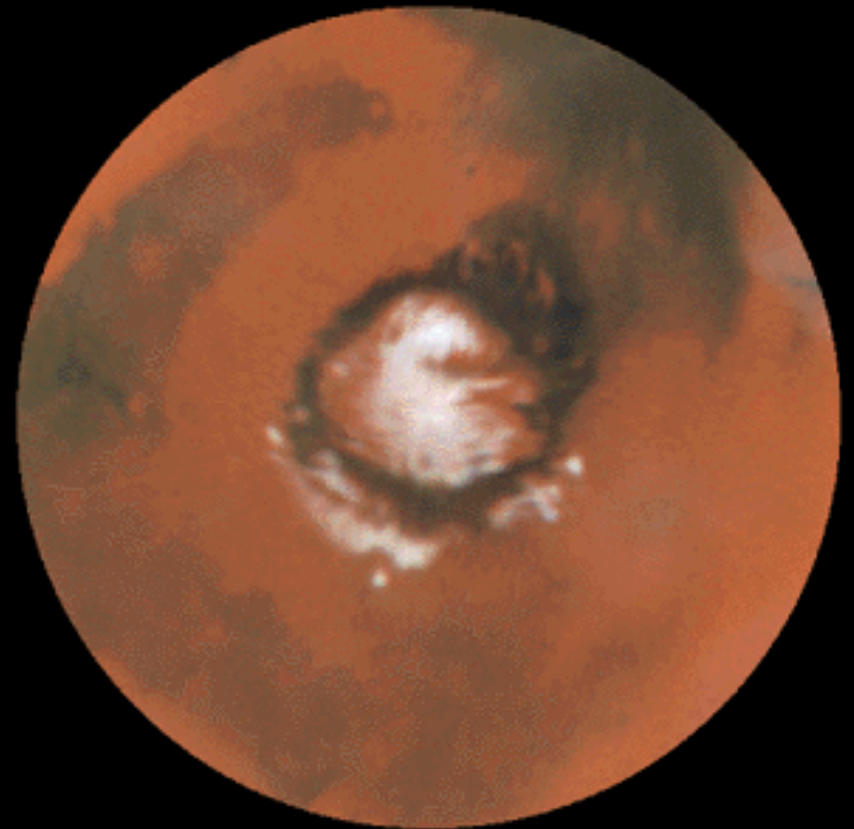
# Visible Data – North Arctic



## Seasonal Changes at the North Arctic



Northern Winter



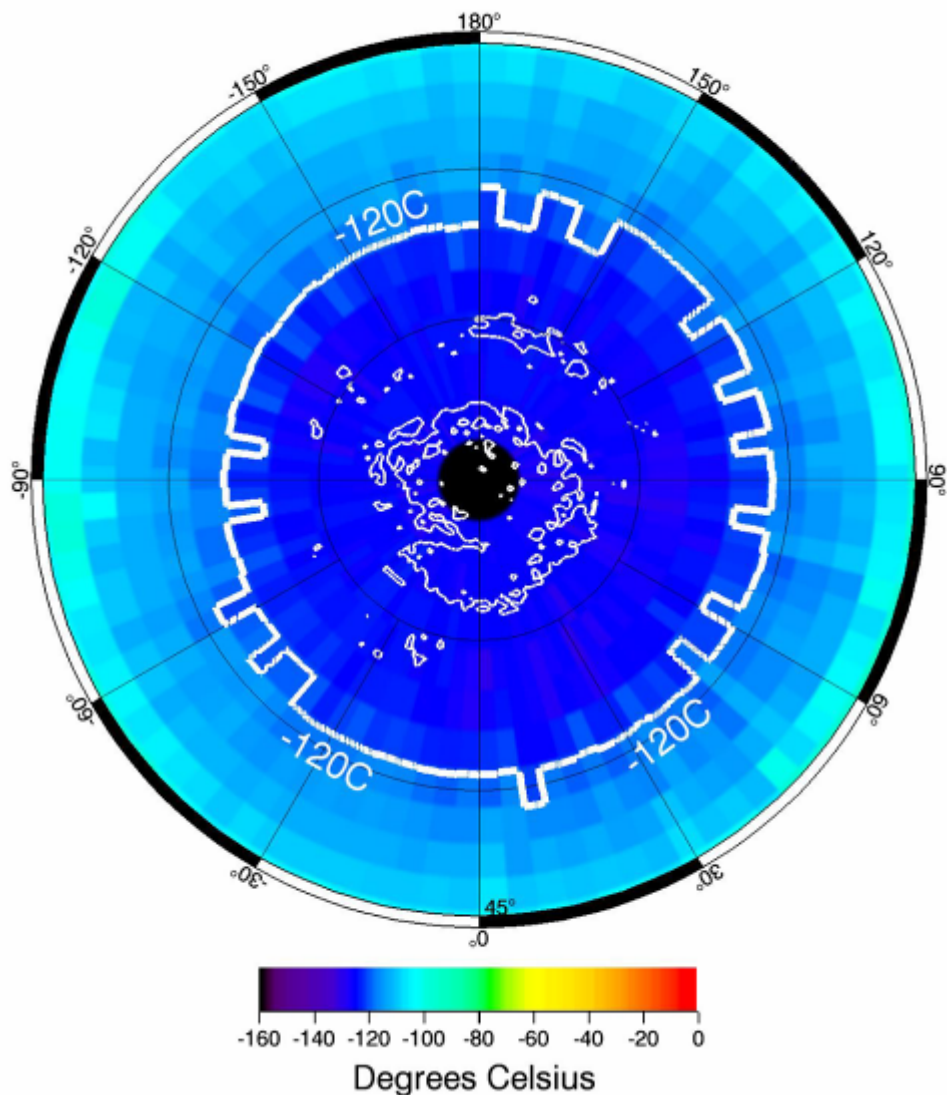
Northern Summer



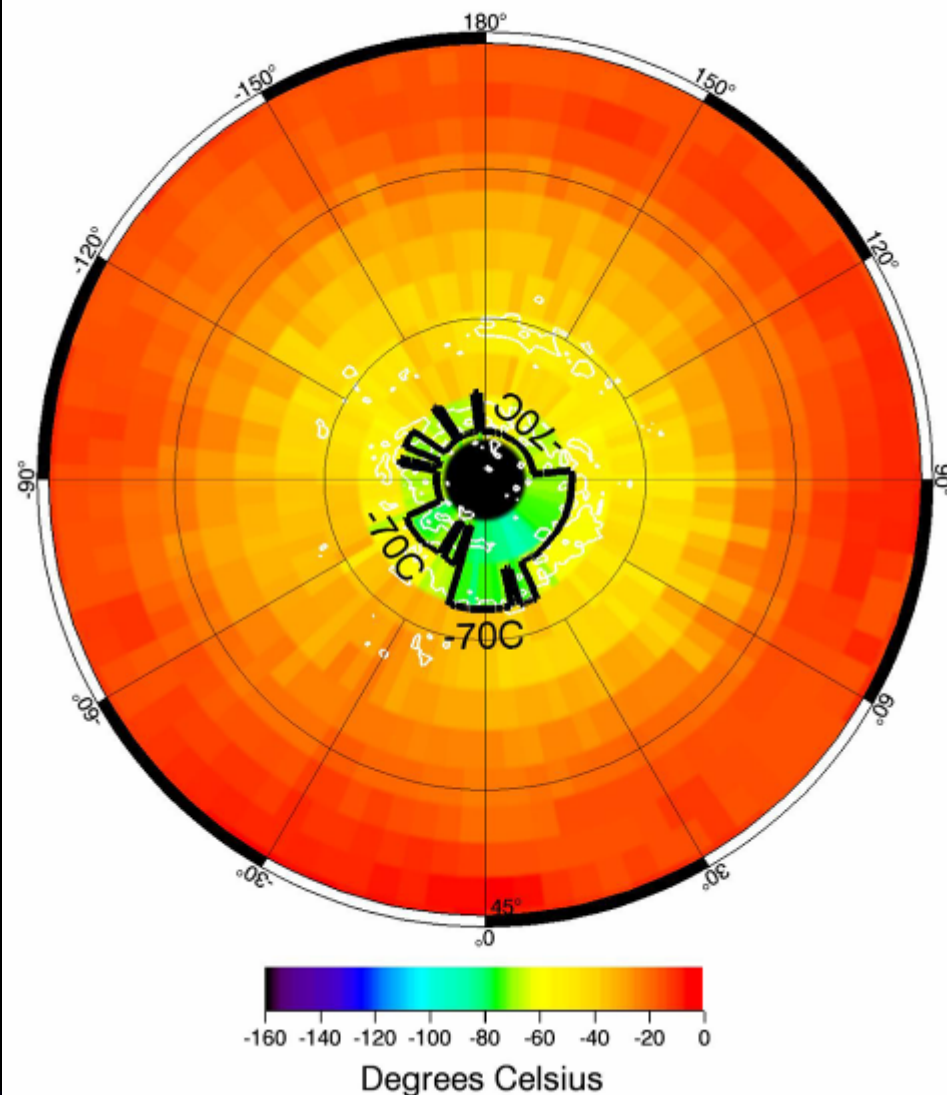
# Infrared Data – North Arctic



North Pole Winter - TES Surface Temperature



North Pole Summer - TES Surface Temperature

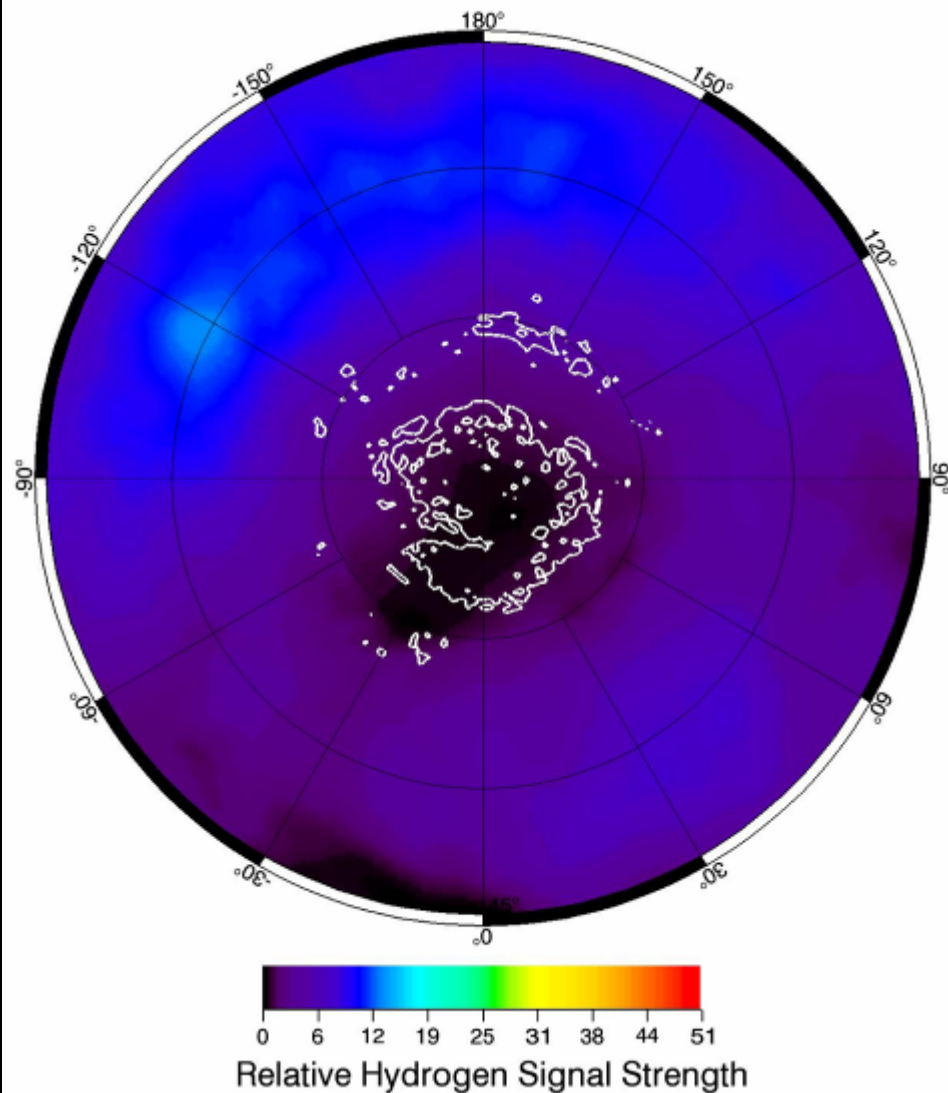




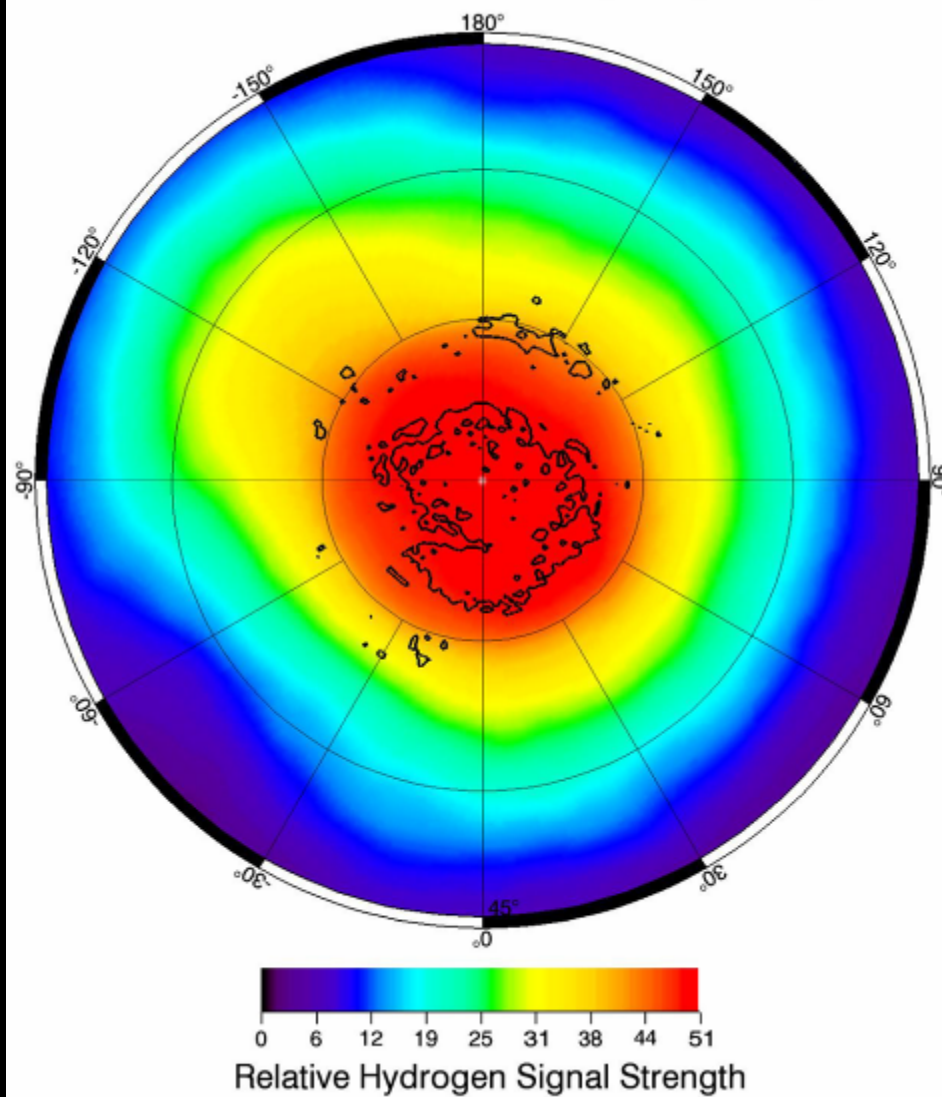
# Gamma Ray Data – North Arctic



North Pole Winter - GRS Hydrogen Signal

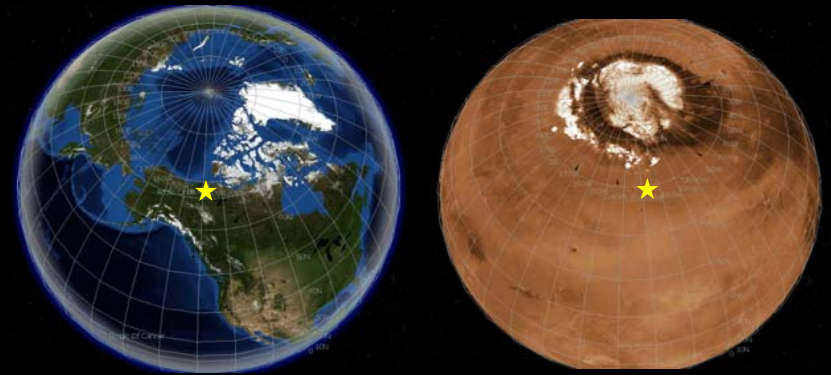


North Pole Summer - GRS Hydrogen Signal



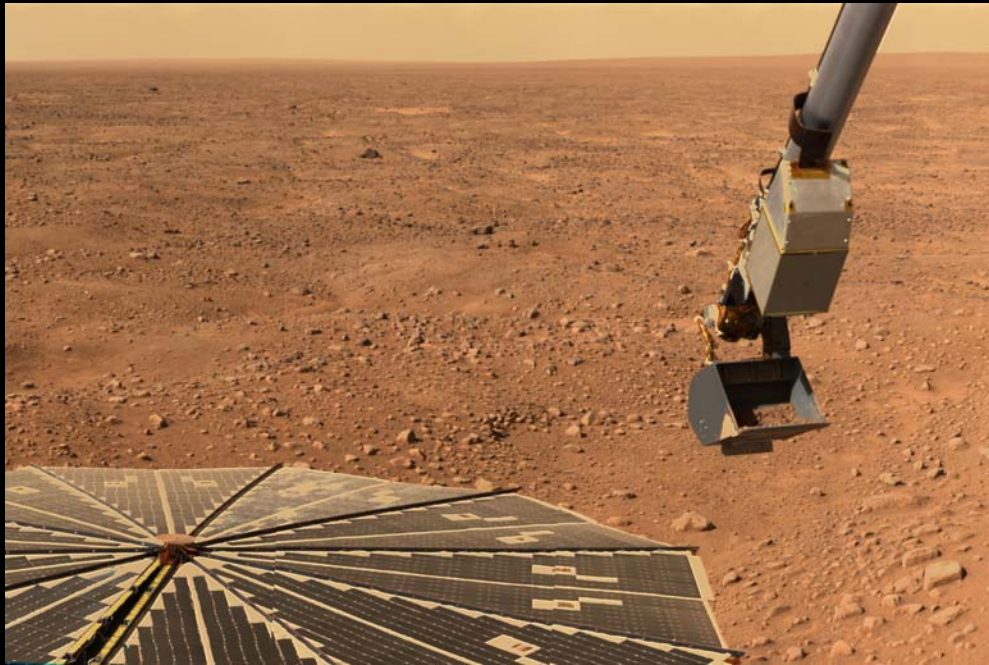


# Phoenix Mars Lander Arrives at 68°N





# Trench reveals buried water ice



Sol 20

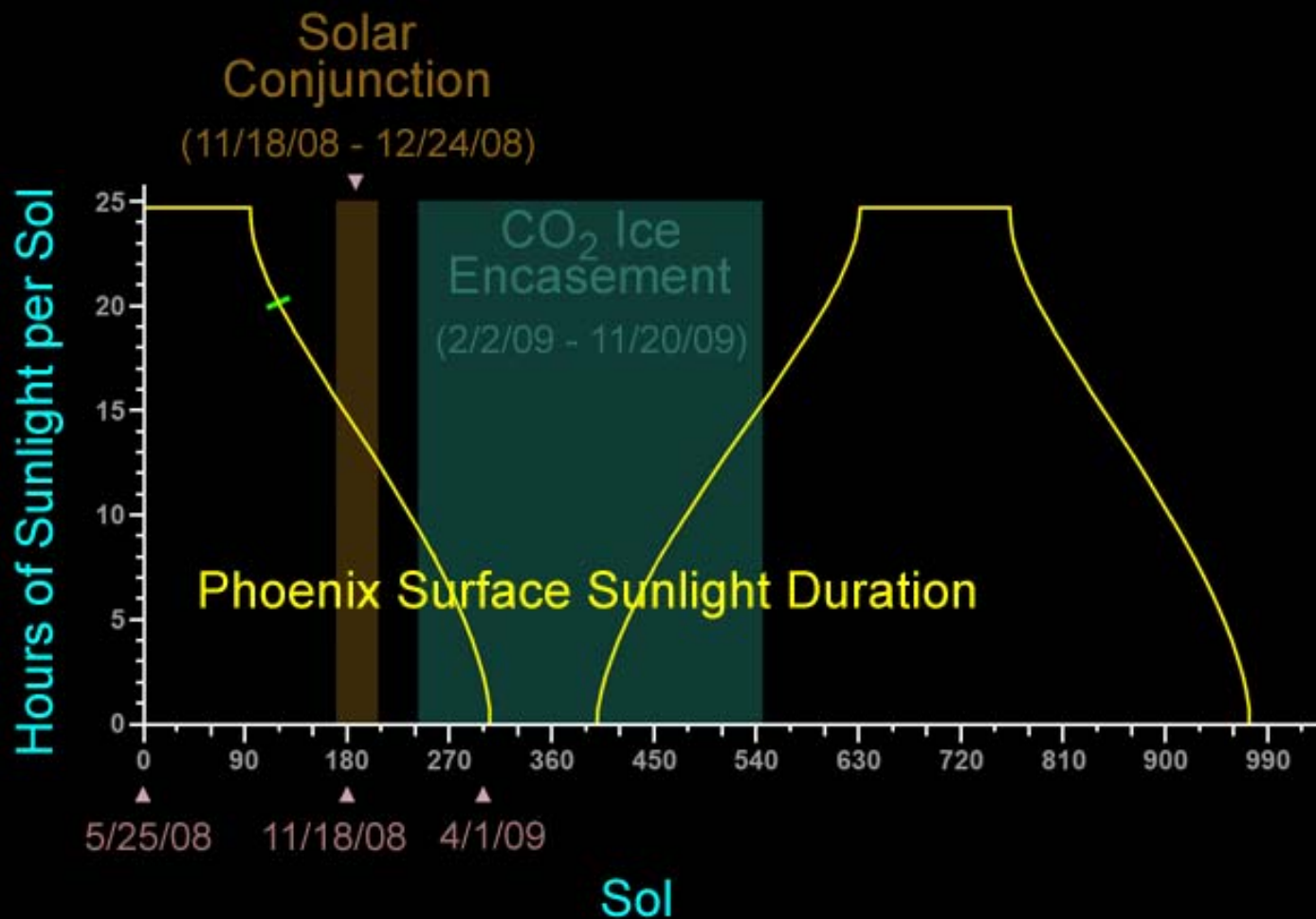


Sol 24





# Harsh Winter for Phoenix Lander





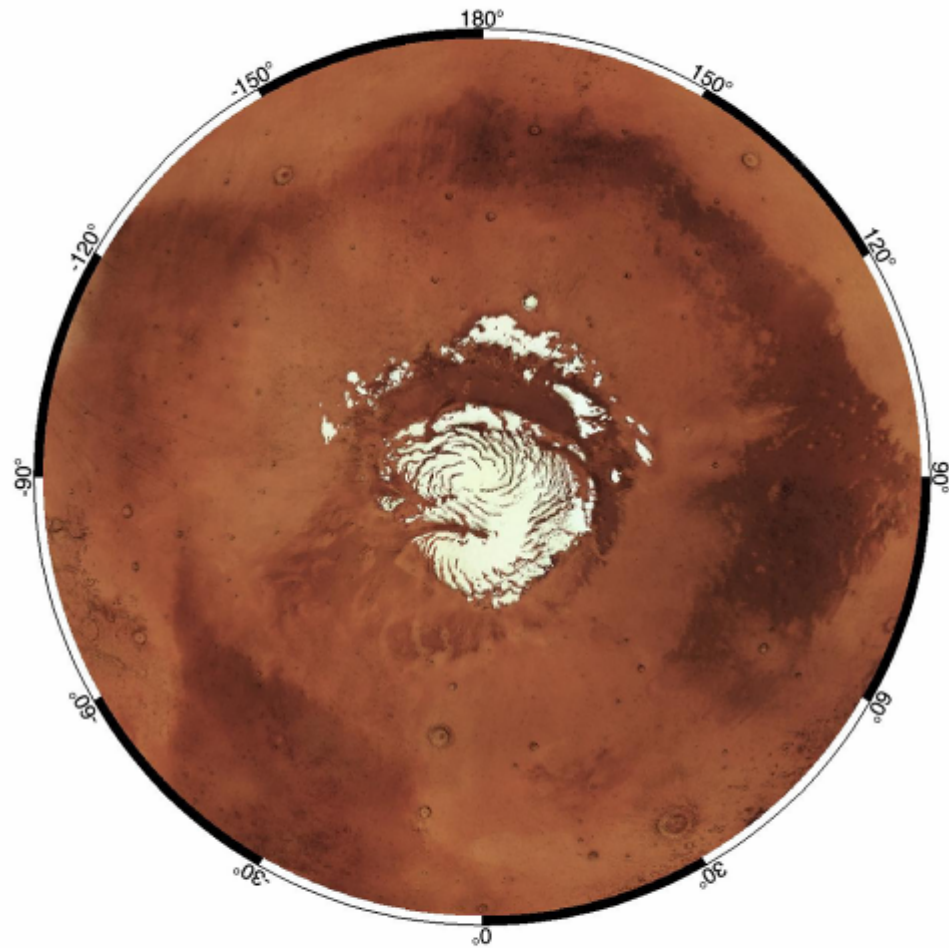
# False color maps of southern arctic



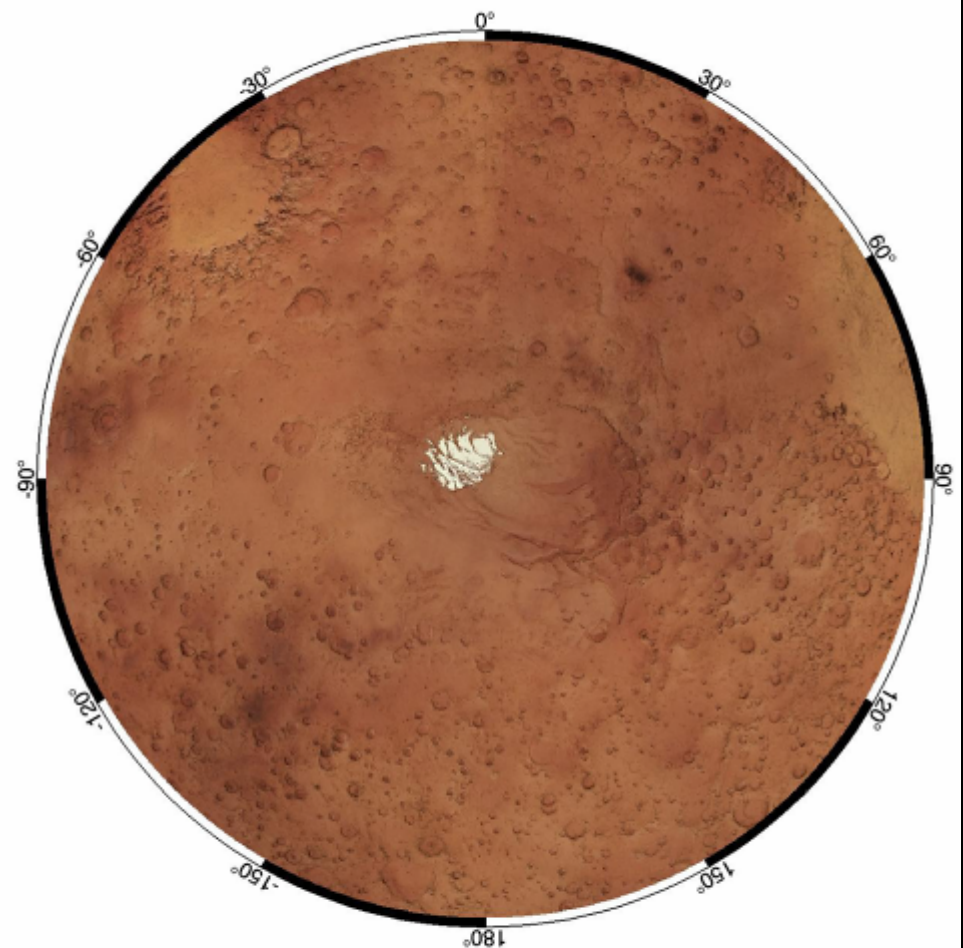
# Visible Data – North and South Arctic Summer



North Pole Summer Visible Mosaic



South Pole Summer Visible Mosaic





# South Arctic Ice Cap Temperatures



Season	South Arctic Ice Cap Temperature	South Arctic Ice Cap Composition
Winter	Around -125°C	
Summer	Around -125° C	



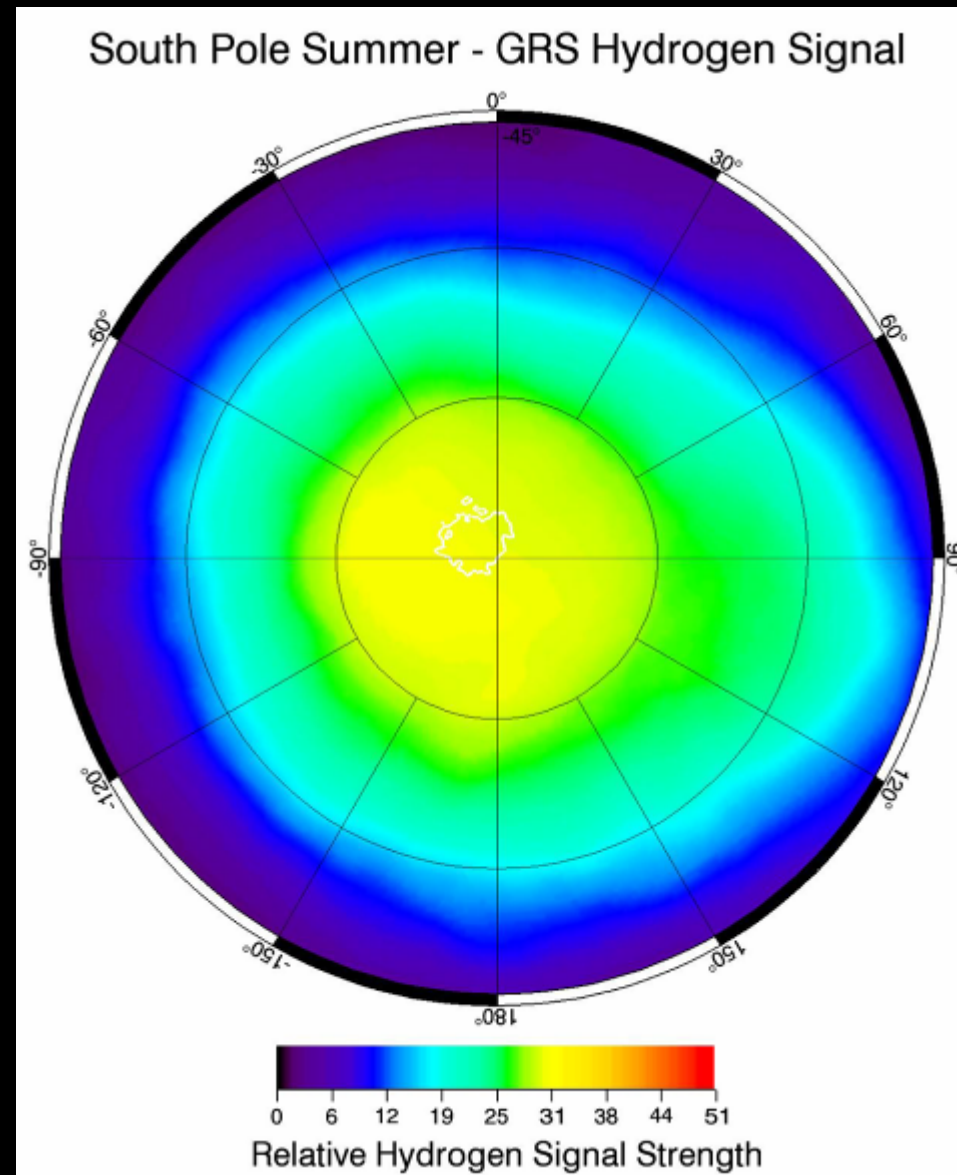
# South Arctic Ice Cap Composition



Season	South Arctic Ice Cap Temperature	South Arctic Ice Cap Composition
Winter	Around -125°C	CO <sub>2</sub>
Summer	Around -125° C	CO <sub>2</sub>



# Gamma Ray Data – South Arctic Summer



# ***Water on Mars***



**Remote Sensing Ices on Mars**



# Remote Sensing Ices on Mars Student Guide



## Background Reading

Life as we know it requires water. A key NASA science goal is to study past and current water on Mars. Liquid water is unstable under current Mars conditions. This is because temperatures are too cold and the air pressure is too low. However, solid water, known as water ice, and other types of ice can be stable. Studying these ices helps us understand what Mars is like today and may have been like in the past.

## Ice Properties

In this activity, we will look at the types of ice found at high latitudes on Mars. We will also study how the ice caps on Mars change during different seasons. We will consider four different substances that could form ice: water, carbon dioxide, ammonia, and methane. The table below lists properties for each of these if they were solid ices near the surface of Mars.

Substance	Chemical Formula	Visible Brightness	Martian Frost Point Temperature
Water	H <sub>2</sub> O	Bright	-75°C
Carbon Dioxide	CO <sub>2</sub>	Bright	-123°C
Ammonia	NH <sub>3</sub>	Bright	Around -200°C
Methane	CH <sub>4</sub>	Bright	Around -220°C

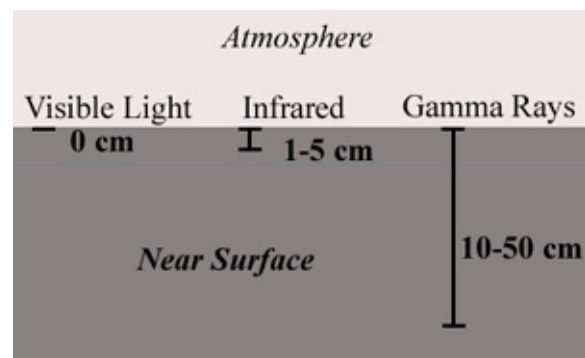
The table above gives the name and chemical formula of each type of ice. Notice that each ice would appear bright at the surface of Mars. However, each has a different frost point temperature. The frost point temperature is the temperature that the substance changes from solid to gas. This temperature is related to the energy needed to break chemical bonds and the amount of

gas in the atmosphere. We will be able to tell the difference between water ice and other ices by its surface temperature.

## Types of Data

The information in this activity was collected by spacecraft orbiting Mars. We will look at Mars using three different energies of light – visible, infrared, and gamma ray light. Visible photographs will help us locate ice caps on Mars. At visible wavelengths, all of the ices listed in the table appear brighter than Martian rocks and soils. Next, we will use infrared light to figure out the surface temperature of an ice cap during different seasons. Because different ices have different frost point temperatures, the surface temperature of an ice cap tells us what it is made of. Finally, we will use gamma ray light to figure out where hydrogen is present. This will help us find buried ice near the surface of Mars.

It is important to realize that we can see deeper into the Martian surface with different types of light. Look at the figure below. Visible light reflects from the very top of the surface. Infrared light comes from within the top millimeter. However, gamma ray light comes from beneath the surface as far down as a few tens of centimeters. Gamma rays allow us to detect ice buried below the surface of Mars.





# Remote Sensing Ices on Mars Student Guide



## Reading Questions

- 1) What is another name for solid water? Why is solid water more likely to be found on the surface of Mars than liquid water?
- 2) Can you tell the difference between various types of ice based upon visual appearance alone? Why or why not?
- 3) What is the frost point temperature? How can we use the frost point temperature to figure out what an ice cap is made of?
- 4) What are the three energies of light discussed in the reading? Which of these can measure the deepest into the surface of Mars and how deep can it measure?





# Remote Sensing Ices on Mars Student Guide

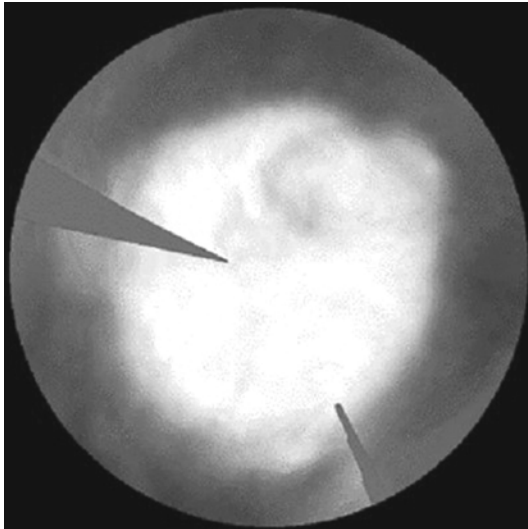


## North Pole Analysis

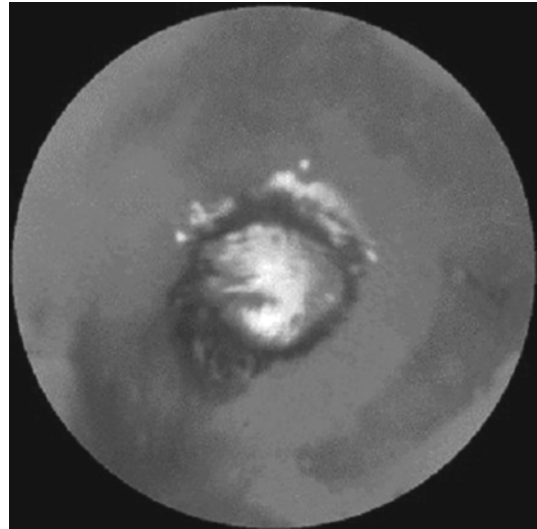
### Part 1: Visible Data

The maps below show the visible surface of the North Pole of Mars (down to 45°N) during winter and summer. Each map is a mosaic of visible images taken with the Hubble Space Telescope (HST). The two dark pie-piece wedges in the winter map represent missing data where HST was not able to collect images to include in the mosaic.

**North Pole Winter – HST Visible Mosaic**



**North Pole Summer – HST Visible Mosaic**



- 1) Draw a circle around the location of the polar ice cap during each of the seasons above. How can you tell the difference between polar ice and surrounding rock and soil?
- 2) Is the ice cap larger during the winter or during the summer? Give a possible explanation for this observation.
- 3) Can you determine whether the winter and summer ice caps are made of carbon dioxide ice, methane ice, ammonia ice, or water ice based only upon the visual images above? Explain your reasoning.





## Remote Sensing Ices on Mars Student Guide



4) Do you agree or disagree with either or both of the students below? Explain your reasoning.

*Student 1:* I think the ice caps are made of water ice. There is more water ice in the winter when it is colder and less in the summer, just like on Earth.

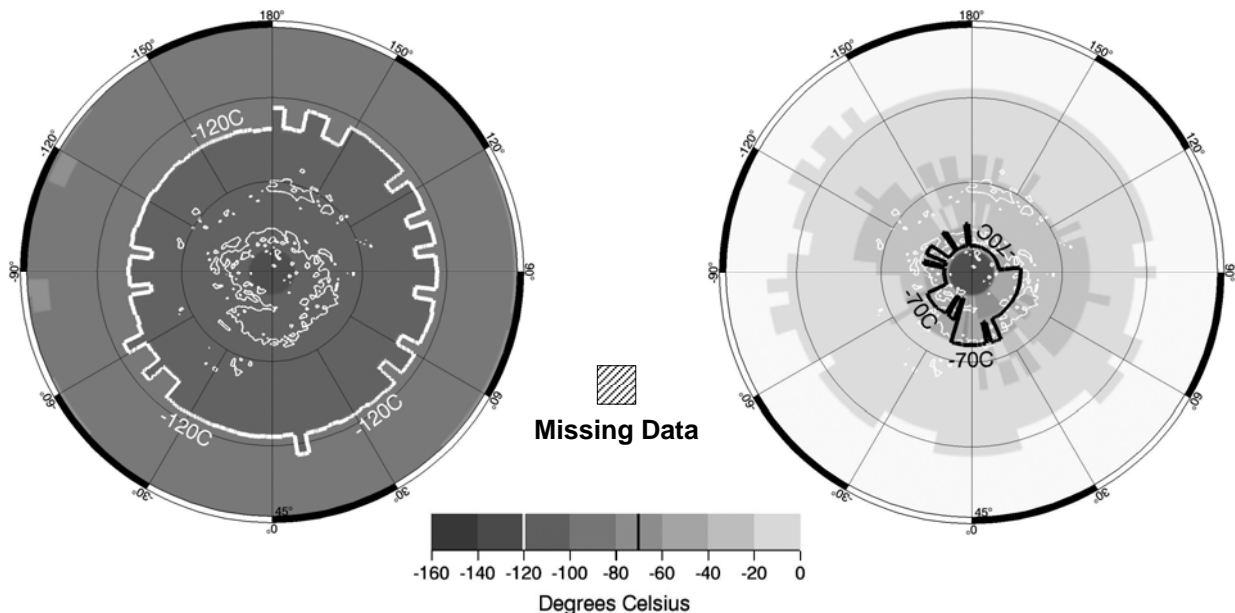
*Student 2:* I don't think we can figure out what kind of ice the caps are made of because other ices, like carbon dioxide and methane, are also bright just like water ice.

### Part 2: Infrared Surface Temperature Data

The maps below show the surface temperature of the North Pole of Mars (down to 45°N) during winter and summer. This information is based upon infrared light collected by the Thermal Emission Spectrometer (TES) orbiting aboard the Mars Global Surveyor spacecraft. Notice that the scale bar shows the surface temperatures that each shade of gray represents. Contour lines are drawn at temperatures of -120°C (white) and -70°C (black). Note also that TES did not collect data from the dashed regions on each map. The permanent ice cap you noticed in the summer visible image before has been outlined in white on both maps.

North Pole Winter – TES Surface Temperature

North Pole Summer – TES Surface Temperature



5) Do “darker” shades of gray represent warmer or colder surface temperatures? Explain why it makes sense that the winter temperature map is darker than the summer temperature map.





# Remote Sensing Ices on Mars Student Guide



- 6) What is the surface temperature of the ice cap during the winter?

During the summer?

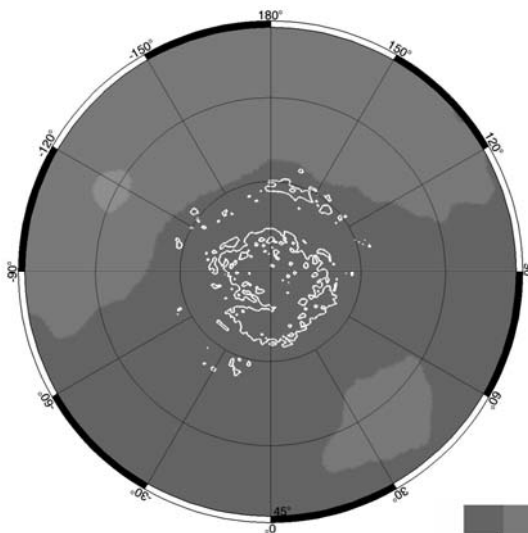
- 7) Based upon the background reading on frost point temperature, what is the most likely chemical formula of the ice found at the surface of the ice cap during the winter? Explain your reasoning.

During the summer? Explain your reasoning.

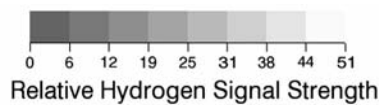
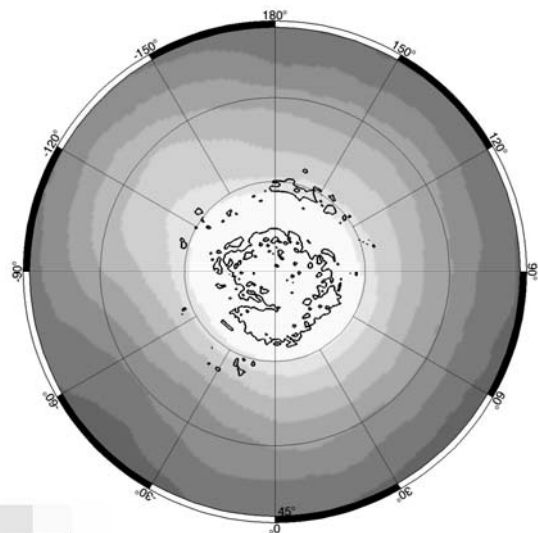
## Part 3: Gamma Ray Data

The maps below show the hydrogen signal strength at the North Pole of Mars (down to 45°N) during winter and summer. This information is based upon gamma ray light collected by the Gamma Ray Spectrometer (GRS) orbiting aboard the 2001 Mars Odyssey spacecraft. The permanent ice cap you noticed in the summer visible image before has been outlined on both maps.

North Pole Winter – GRS Hydrogen Signal



North Pole Summer – GRS Hydrogen Signal





## Remote Sensing Ices on Mars Student Guide



- 8) Is the hydrogen signal strong or weak during the winter? Why does this make sense given the chemical formula of the ice found at the surface during the winter (see Question 7)?

Is the hydrogen signal stronger or weaker during the summer? Why does this make sense given the chemical formula of the ice found at the surface during the summer (see Question 7)?

- 9) On the summer map, notice that we detect hydrogen even from regions surrounding the permanent ice cap (outlined in black). Give a possible explanation for why the surrounding region with darker rocks and soil at the surface (see Question 1) could still give a strong gamma ray signal from hydrogen. Keep in mind the different depths that visible and gamma ray light measure.

- 10) Do you agree or disagree with either or both of the students below? Explain your reasoning.

*Student 1:* I think that water signal goes away in the winter because the water ice melts and evaporates into the atmosphere.

*Student 2:* That doesn't make any sense because it's colder in the winter. I think that both the water ice in the summer cap and the water ice buried below the surrounding rock and soil get covered up during the winter by a thick layer of carbon dioxide, which doesn't have any hydrogen in it.





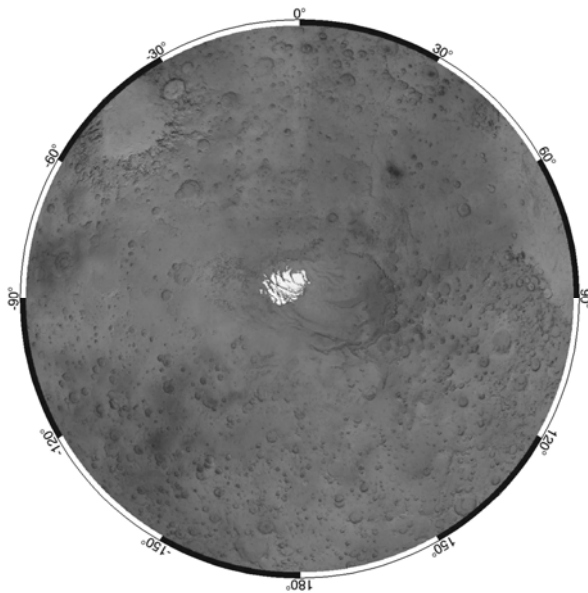
# Remote Sensing Ices on Mars Student Guide



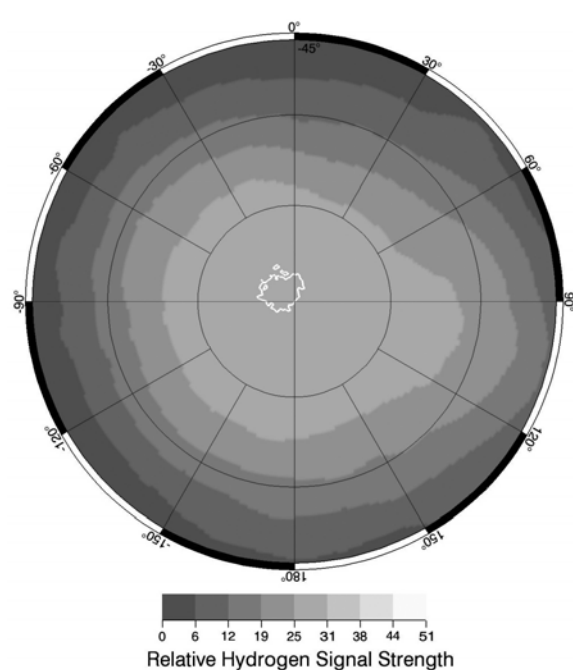
## South Pole Analysis

Be sure to complete the North Pole Analysis activity first. The map below on the left shows the visible surface of the South Pole of Mars (down to 45°S) during summer. This information is based upon data taken by the Mars Orbiter Camera (MOC) orbiting aboard the Mars Global Surveyor spacecraft. The map below on the right shows the hydrogen signal strength for the same region and season. This information is based upon gamma ray light collected by the Gamma Ray Spectrometer (GRS) orbiting aboard the 2001 Mars Odyssey spacecraft.

South Pole Summer – MOC Visible Mosaic



South Pole Summer – GRS Hydrogen Signal



- Just like in the north, the South Pole ice cap grows significantly during the winter (not shown). The table below summarizes the approximate surface temperature of the ice cap during winter and summer. Complete the table by listing whether the ice cap is composed of water ice, carbon dioxide ice, methane ice, or ammonia ice.

Season	South Pole Ice Cap Temperature	South Pole Ice Cap Composition
Winter	Around -125°C	
Summer	Around -125°C	





## Remote Sensing Ices on Mars Student Guide




- 2) Are the winter ice caps at the South Pole and North Pole similar or different in composition? Refer to your conclusions from the North Pole Analysis activity and explain your reasoning.

Are the summer ice caps at the South Pole and North Pole similar or different in composition? Explain your reasoning.

- 3) Based upon the maps on the previous page, is water ice present in the regions around the South Pole during the summer? If present, is water ice found on the surface or is it buried? Explain your reasoning.





# CSU Science Teacher and Researcher (STAR) Program:

Summer research internship  
for pre-service/early career science teachers

*Western Regional Noyce Conference  
January 23-25, 2009*

<http://cesame.calpoly.edu/programs-star.html>

# The STAR Program

- ♦ Participate in scientific research at a SF Bay Area or Southern California national lab or research center
  - ♦ June 15 – August 8, 2009
  - ♦ \$4,000 stipend + housing and travel
- ♦ Learn more about inquiry-based science teaching and learning in weekly workshops
- ♦ Become part of a teacher-scientist community of pre-service, early career and in-service teachers, and practicing scientists



Fresno State students Regina Prum and Ernesto Hernandez at the NASA Ames Research Center in Mountain View.

*"The workshops were great for understanding what needs to be done when I become a teacher."*

*- 2007 STAR Intern*

# The STAR Program

- ♦ Research Site Partners
  - ♦ Lawrence Livermore National Laboratory (LLNL)
  - ♦ Sandia National Laboratory
  - ♦ Lawrence Berkeley National Laboratory (LBNL)
  - ♦ NASA Ames Research Center
  - ♦ Jet Propulsion Laboratory (JPL)
  - ♦ Stanford Linear Accelerator Center (SLAC)
  - ♦ SETI Institute
- ♦ Research Projects
  - ♦ Applied research in biotechnology, earth and planetary sciences, energy, engineering, physics, and more



Joshua Elsasser, a Noyce Scholar from CSU Fresno, working at Pacific Northwest National Laboratory

# The STAR Program

## ♦ Requirements

- ♦ CSU science major or secondary science credential student
  - ♦ Junior or senior science or engineering major
  - ♦ Science or engineering graduate accepted to or enrolled in a CSU secondary credential program
  - ♦ Secondary science credential graduate in their early career
  - ♦ Early career science teacher (from CSU credential program)
- ♦ Strong interest in pursuing a 6th - 12th grade science teaching career
- ♦ Minimum 3.0 GPA
- ♦ Three references
- ♦ U.S. citizenship or permanent resident alien status
- ♦ Ability to be placed on a research laboratory team

# The STAR Program

- ♦ Application Process
  - ♦ Applications due on February 9, 2009  
<http://cesame.calpoly.edu/programs-star.html>
  - ♦ Tentative acceptance by March
  - ♦ Final acceptance, pending placement in a research lab, by mid-late April



*"I see how research is done and how to adapt it to my classroom, so my students will be able to learn how scientists do research."*

*- 2007 STAR Intern*

# Program Partners



National Science Foundation  
WHERE DISCOVERIES BEGIN



The California State University  
WORKING FOR CALIFORNIA

