Mars Firn Layers: Insights from Thermal Mapping Studies

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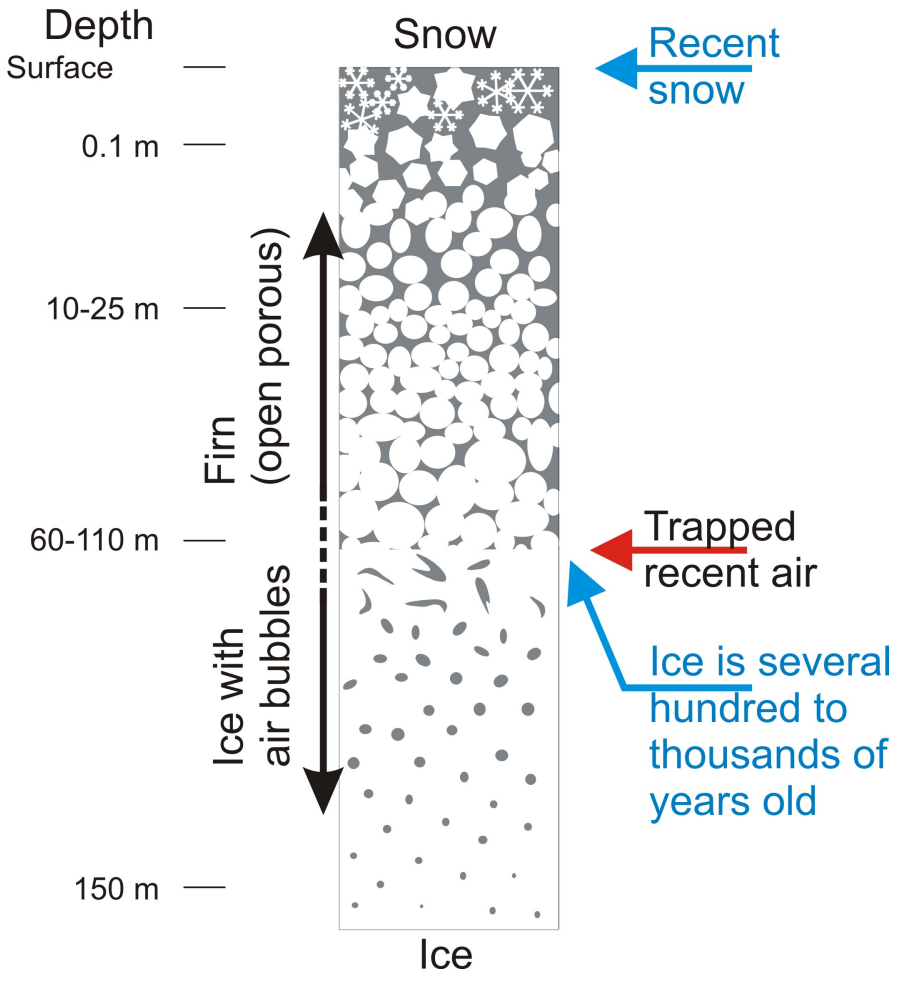
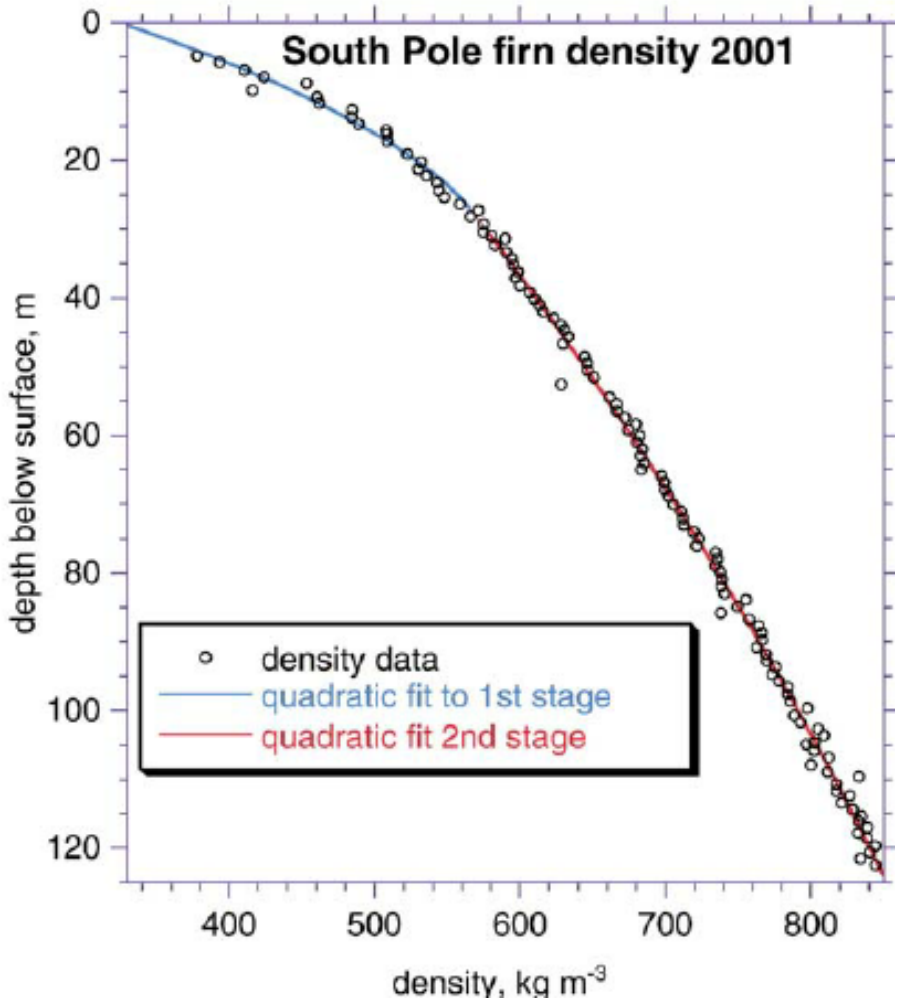
Lightning Talk - The Polar Caps and Climate of Mars
KISS Study, Caltech, August, 2017

Firnification





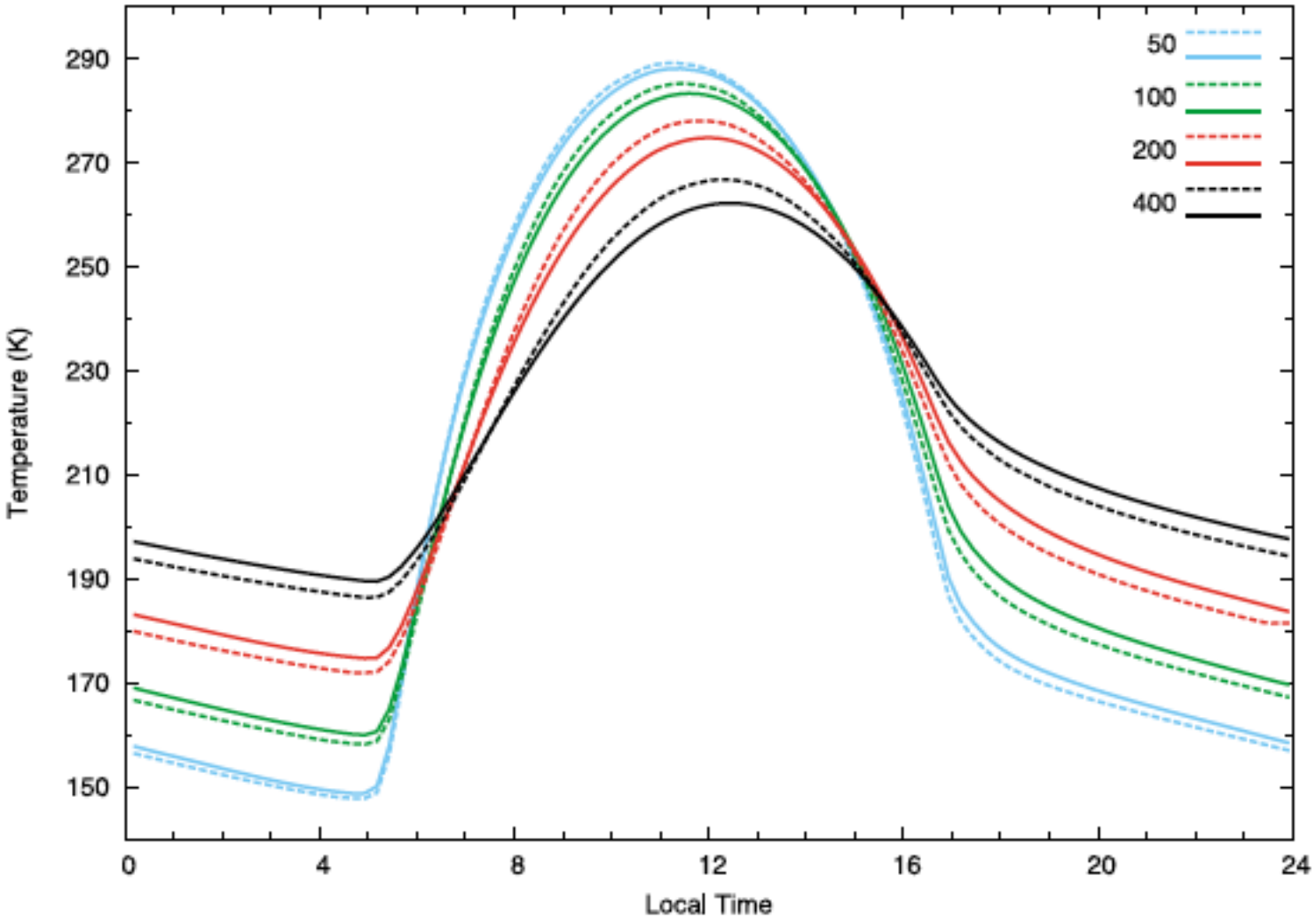
Thermal Inertia

$$I \equiv (k\rho C)^{1/2} \quad [\mathrm{J\ m^{-2}\ K^{-1}\ s^{-1/2}}]$$

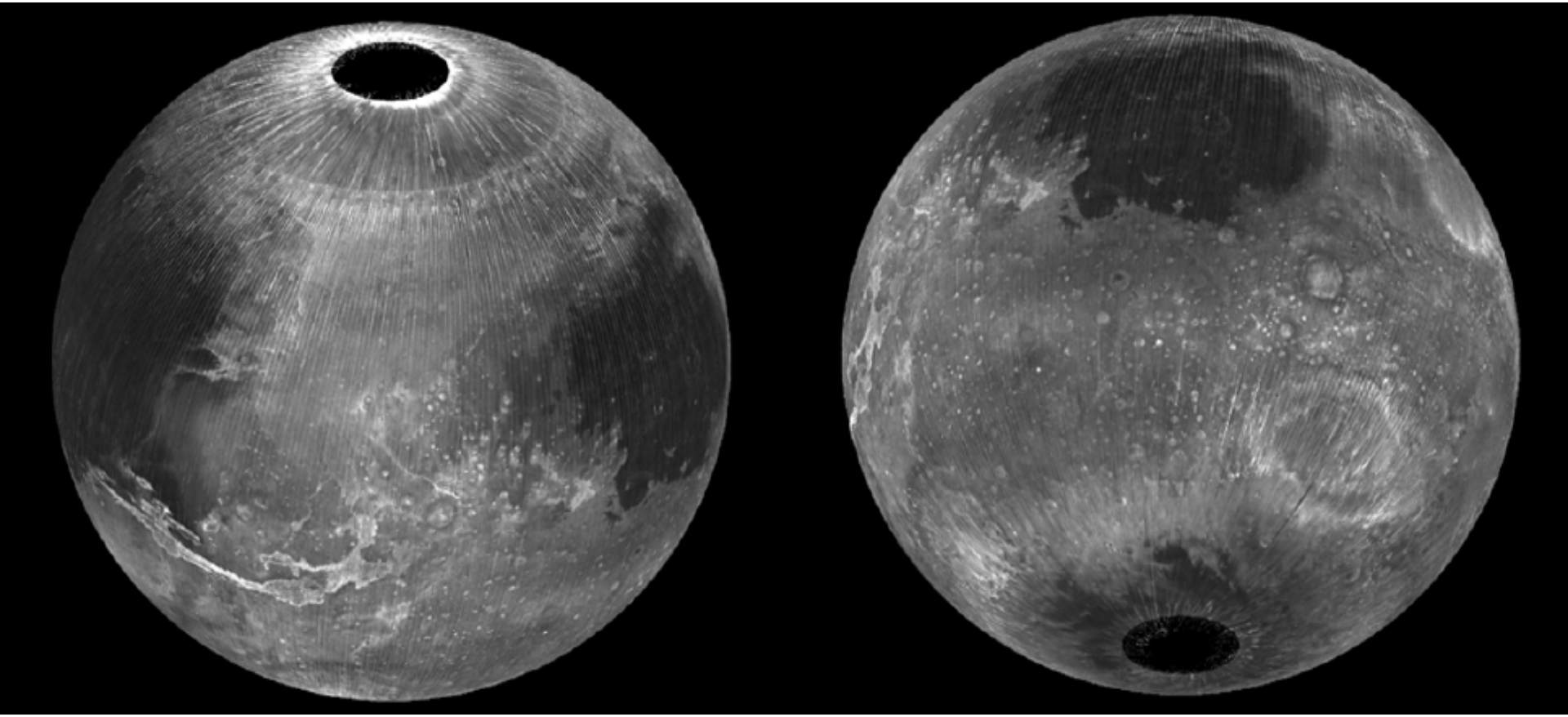
Table 4. Estimates for Expected Variation in Thermal Inertia

Material	Estimated Mean Effective Particle Diameter, μm	Thermal Inertia, MKS	Source
Mars dust	5	40	*Haberle and Jakosky* [1991]
Mars silt	50	125	*Edgett and Christensen* [1991]
Mars fine sand	200	230	*Edgett and Christensen* [1991]
Mars coarse sand	700	375	*Edgett and Christensen* [1991]
Terrestrial sandstone	-	2344	*Carslaw and Jaeger* [1959]
Mars solid ice	-	2045	*Kieffer* [1990]

Mars Diurnal Thermal Skin Depth ~ 10 cm



Piqueux and Christiensen, 2011



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Thermal and albedo mapping of the polar regions of Mars using Viking thermal mapper observations
1. North polar region

David A. Paige, Jennifer E. Bachman, and Kenneth D. Keegan
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JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 99, NO. E12, PAGES 25,993–26,013, DECEMBER 25, 1994

Thermal and albedo mapping of the polar regions of Mars using Viking thermal mapper observations
2. South polar region

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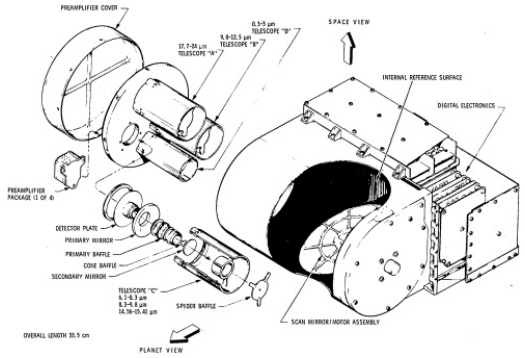
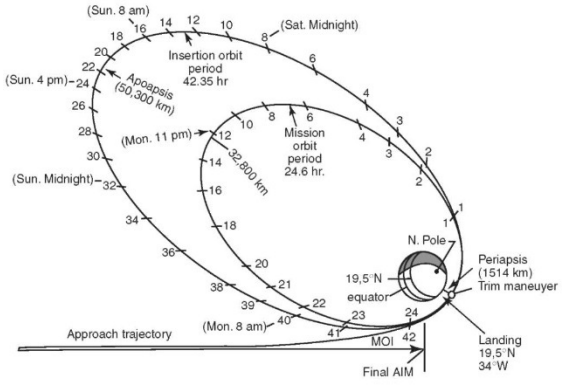




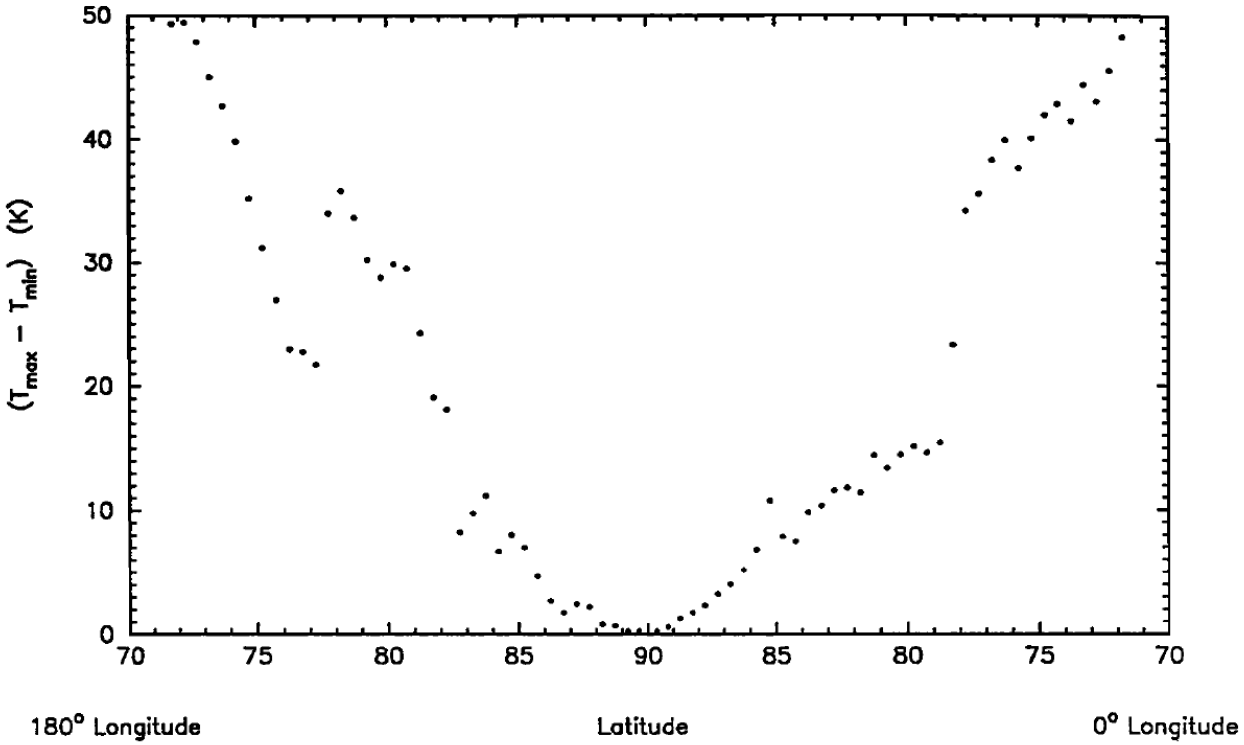
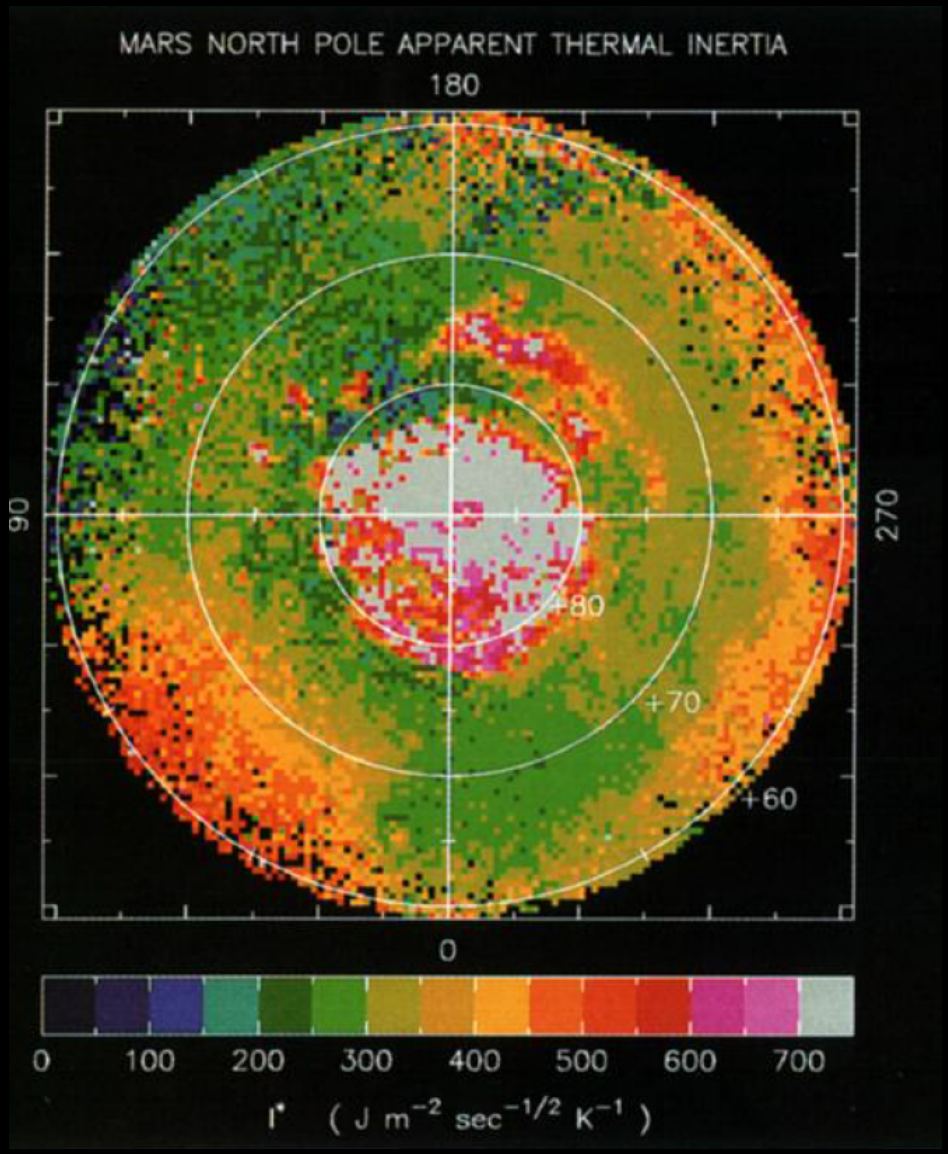
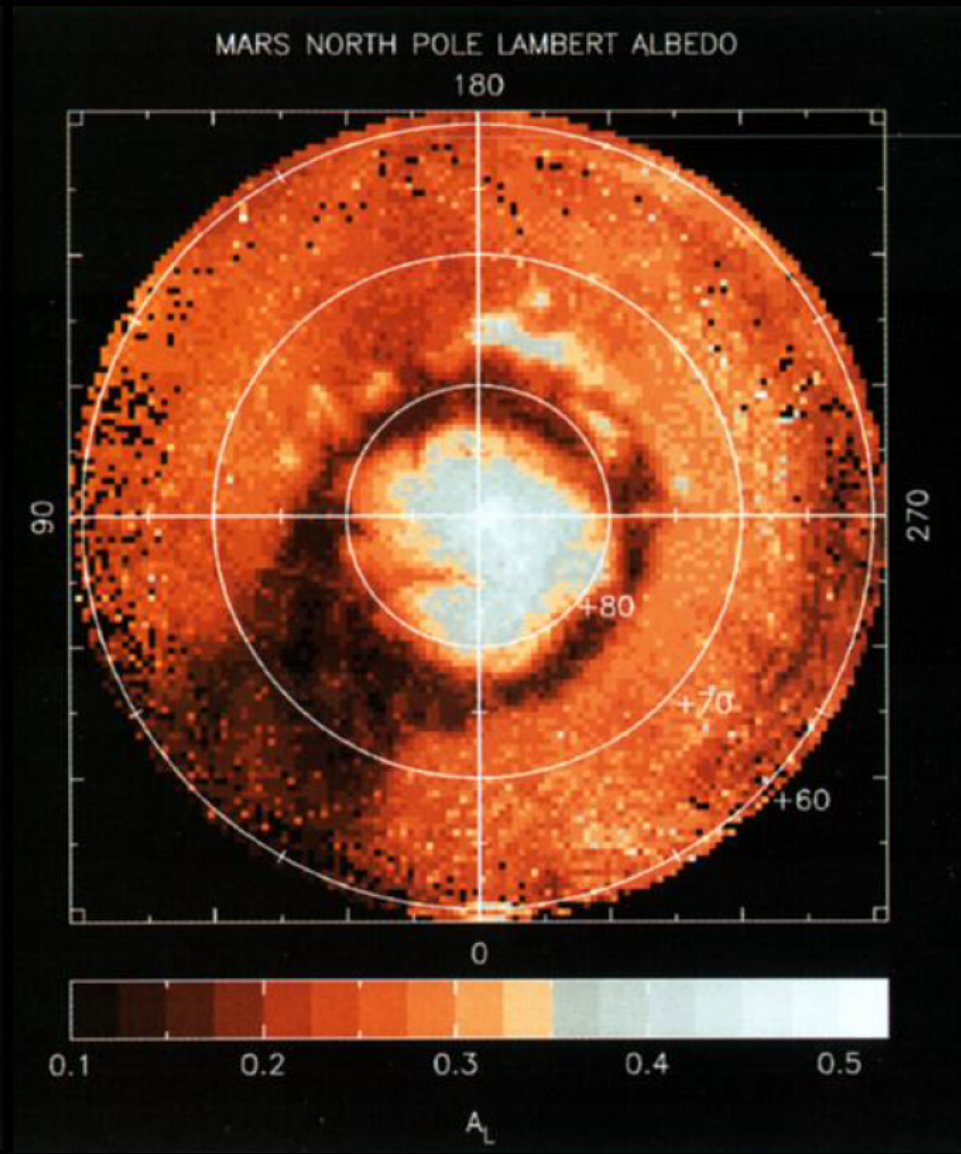
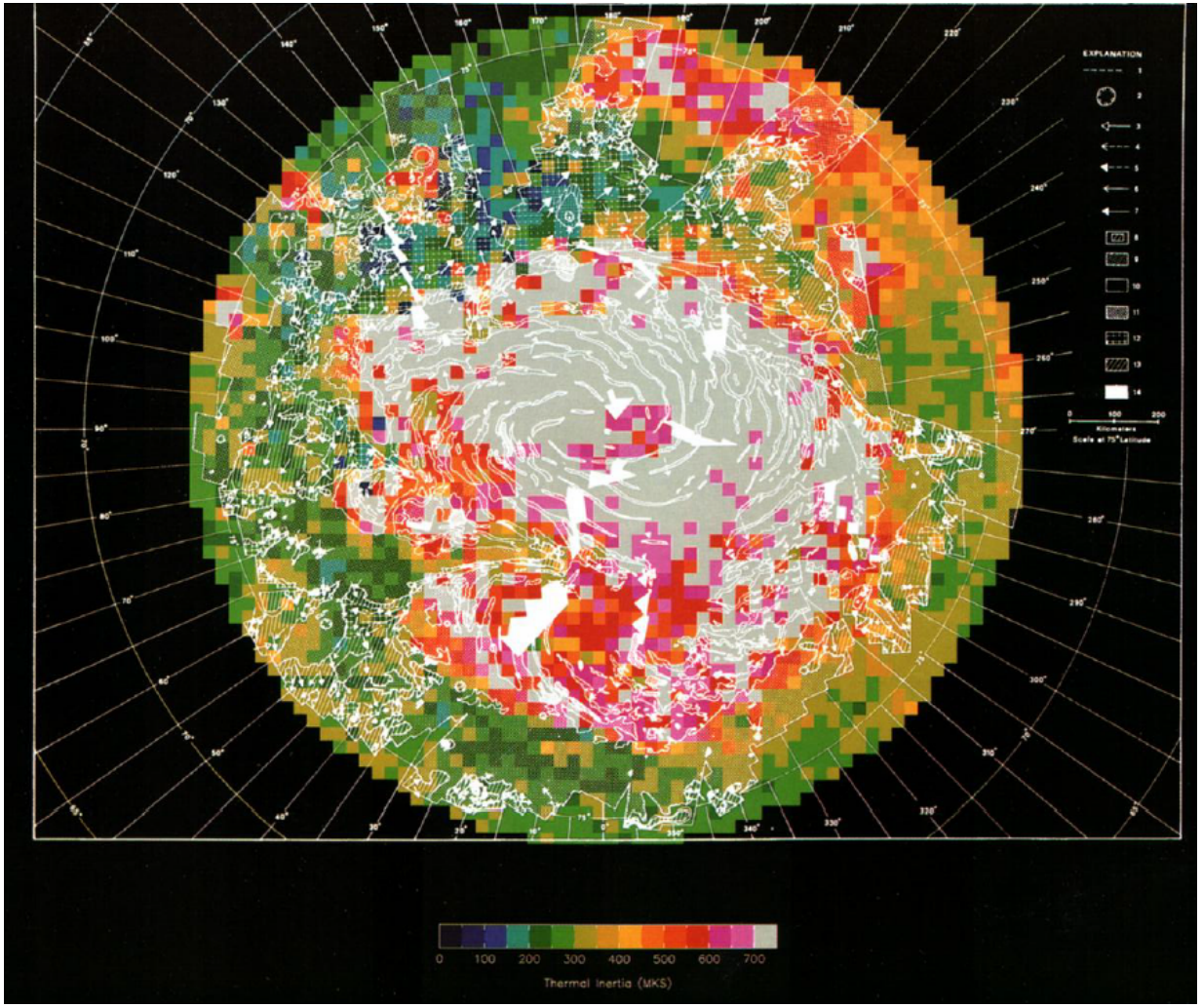


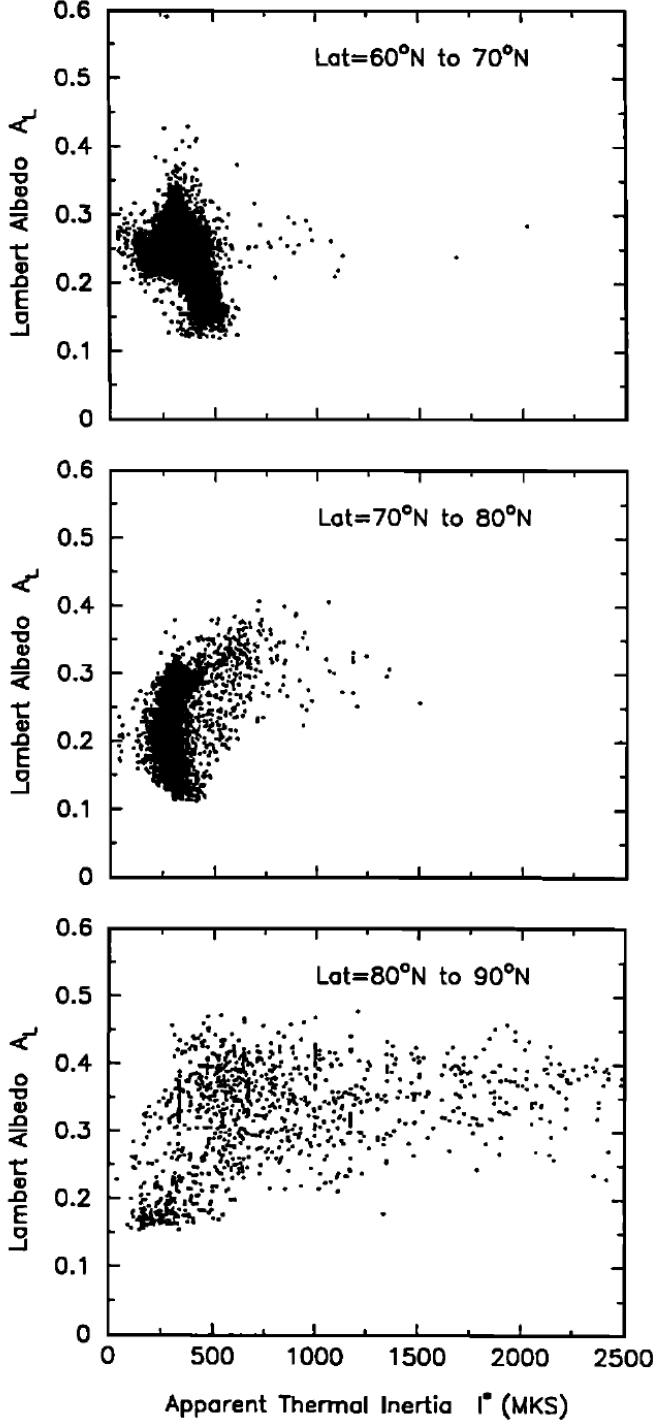
Figure 9. The computed daily range of surface temperature variation (T_{max}-T_{min}) as a function of latitude along the 180° to 0° meridians.

IRTM Polar Spatial Resolution = 0.5 degrees = 30 km

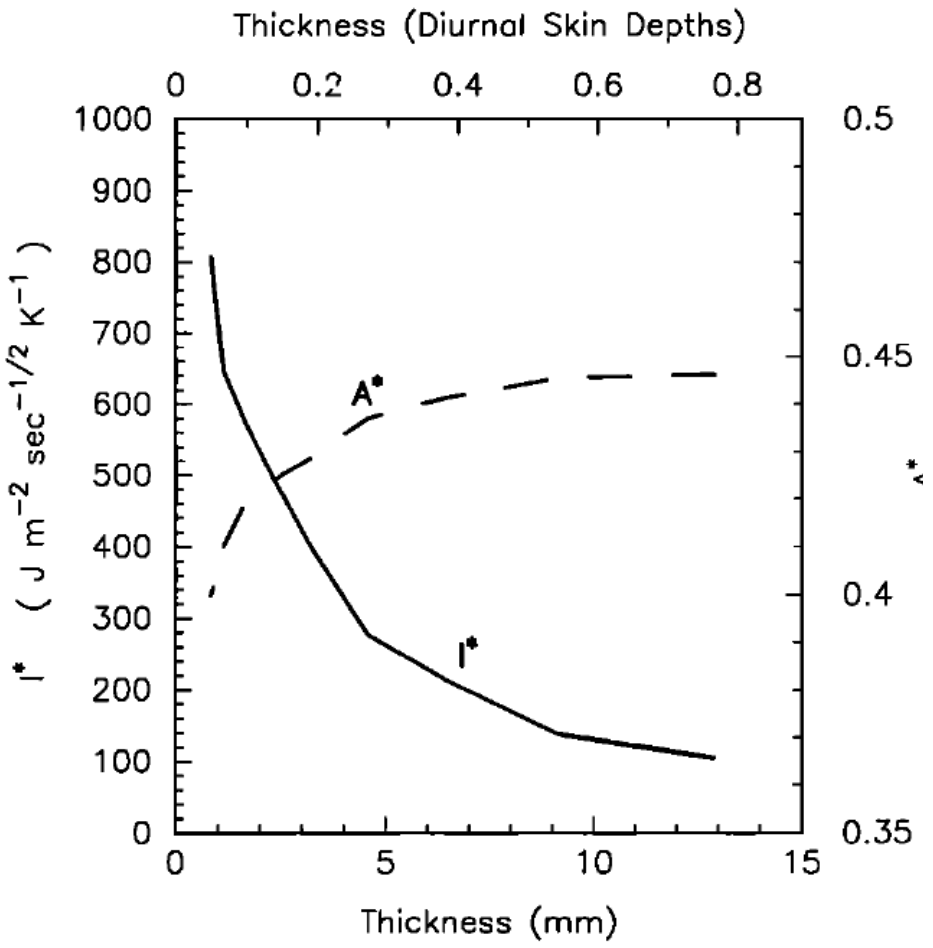

MARS NORTH POLE APPARENT THERMAL INERTIA
180
90
270
0
+80
+70
+60
0
100
200
300
400
500
600
700
I* (J m^{-2} sec$^{-1/2}$ K^{-1})


MARS NORTH POLE LAMBERT ALBEDO
180
90
270
0
+80
+70
+60
0.1
0.2
0.3
0.4
0.5
A_L

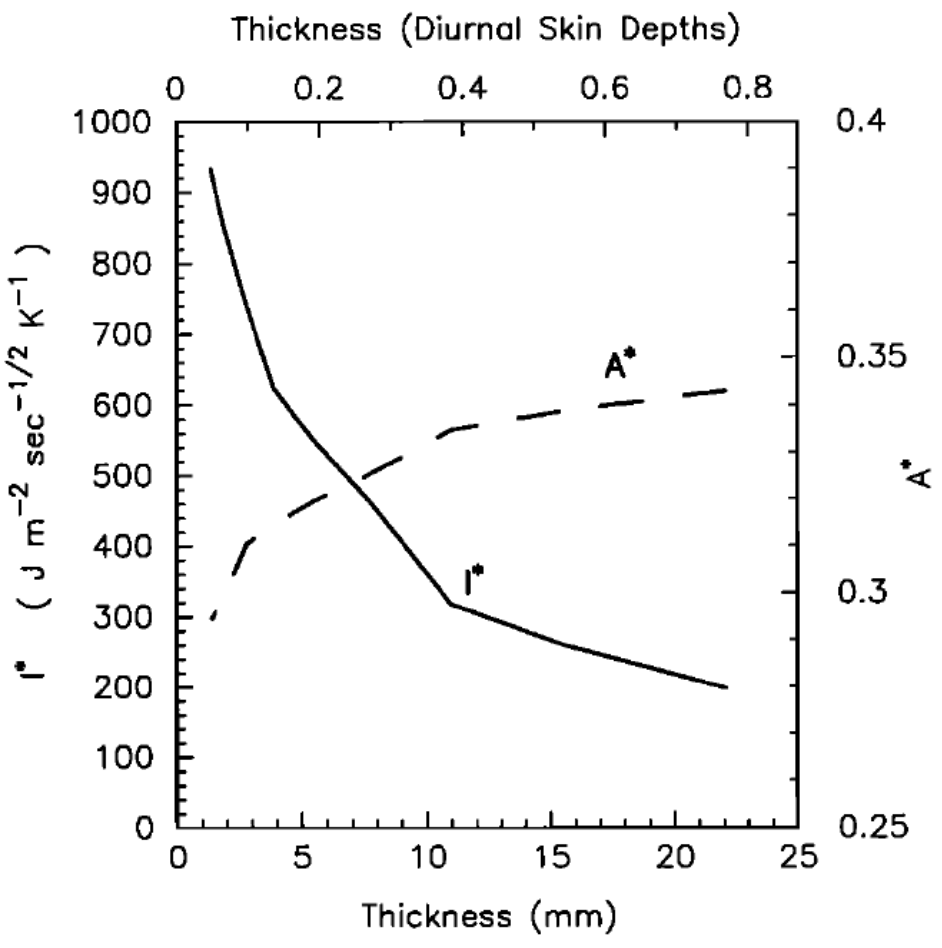

EXPLANATION
0 100 200
Kilometers
Scale at 75° Latitude
0 100 200 300 400 500 600 700
Thermal Inertia (MKS)


Lat=60°N to 70°N
Lat=70°N to 80°N
Lat=80°N to 90°N
Lambert Albedo A_L
0
0.1
0.2
0.3
0.4
0.5
0.6
0
500
1000
1500
2000
2500
Apparent Thermal Inertia I^* (MKS)

TI=100 over TI=1000

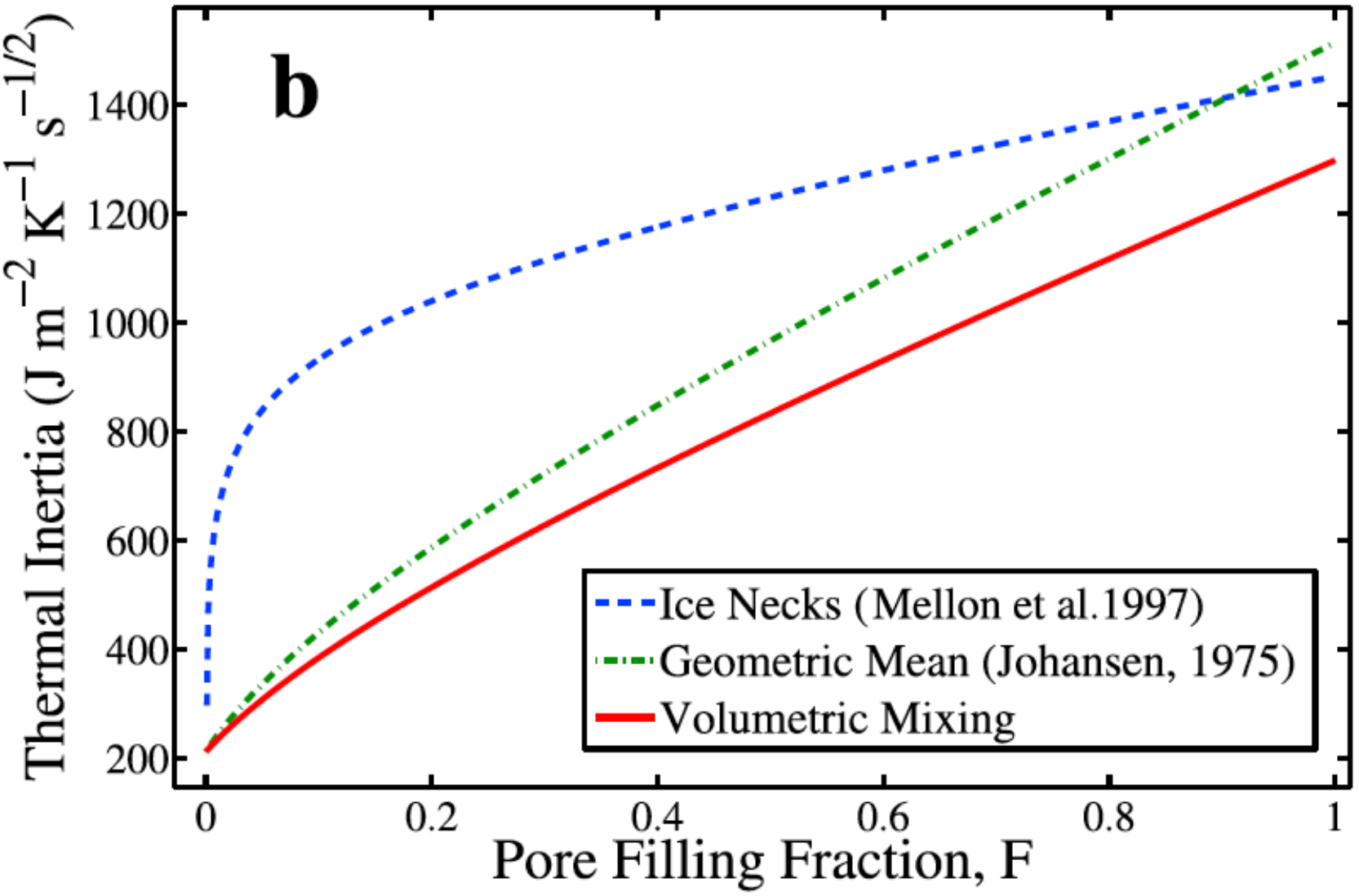


TI=200 over TI=1000

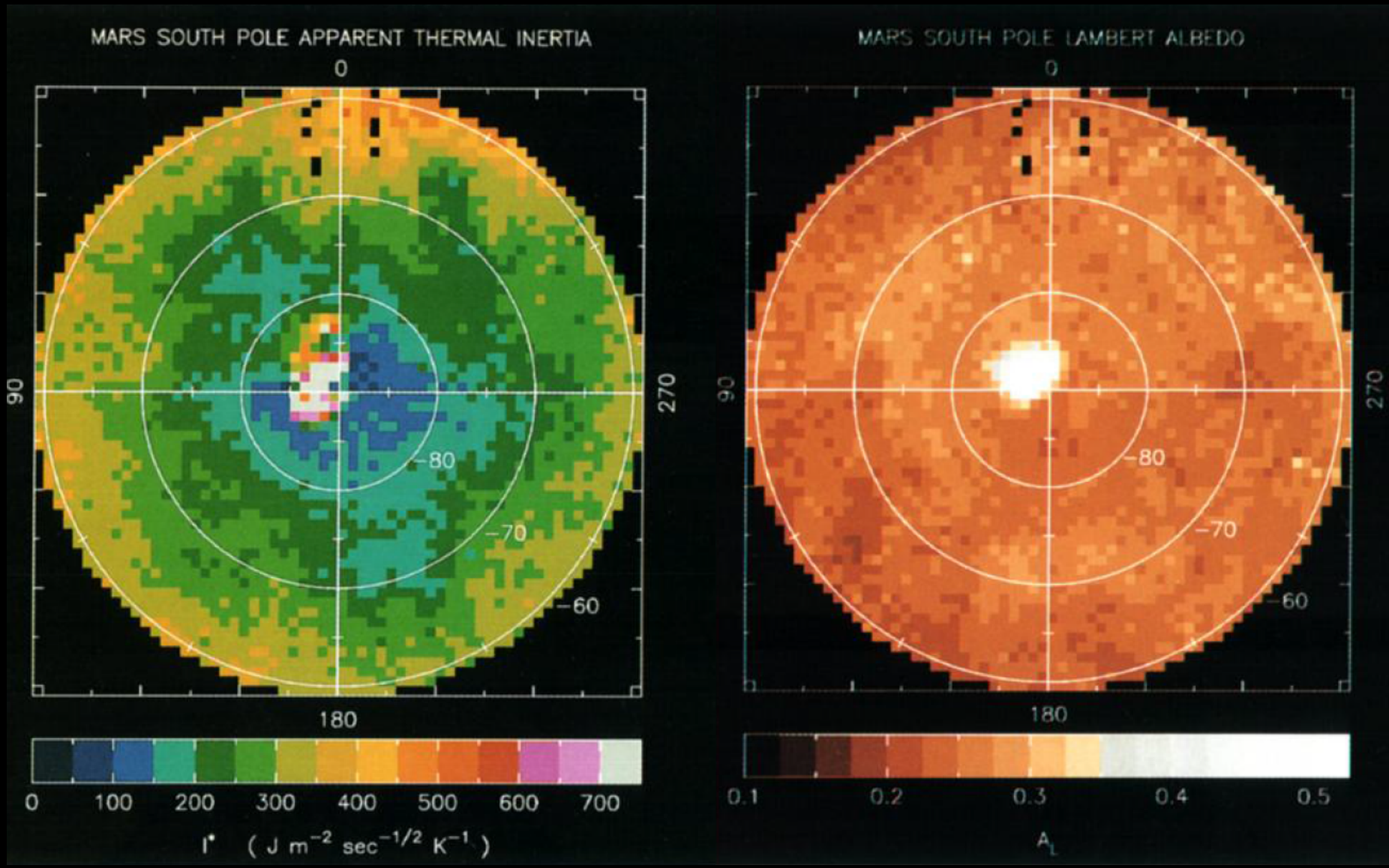


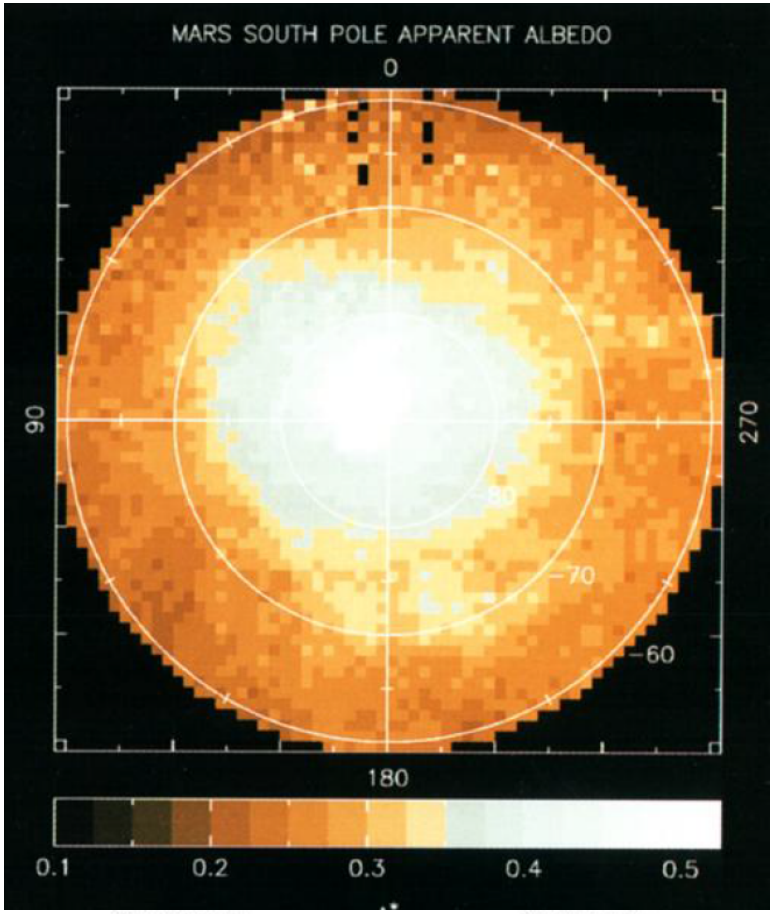
Conclusions:

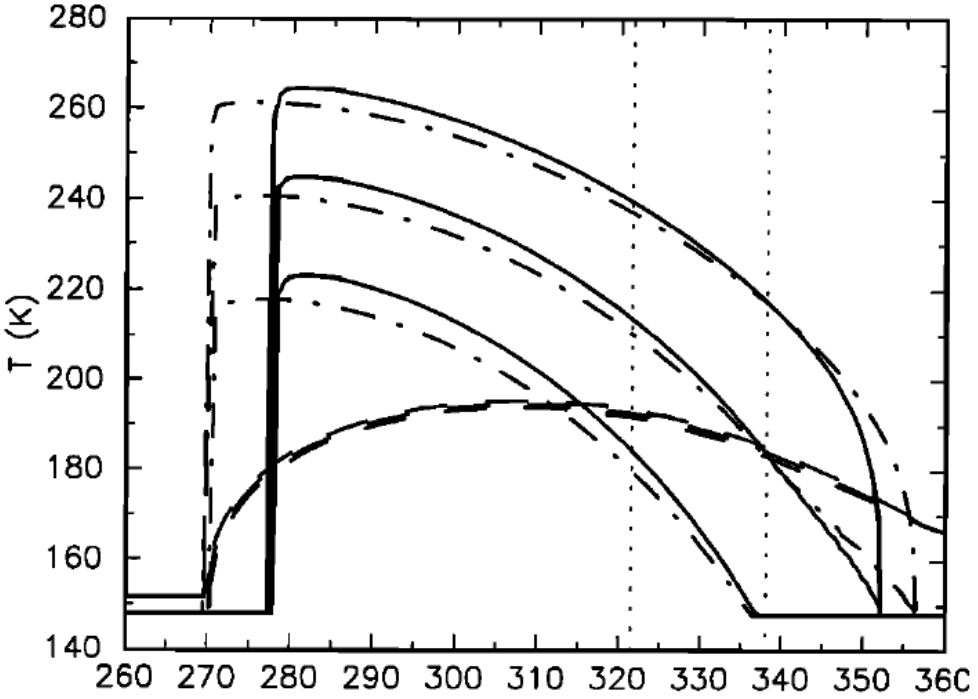
1. North residual cap is high thermal inertia water ice
2. North residual cap ice is covered by at most 2mm of fine-grained ice or snow

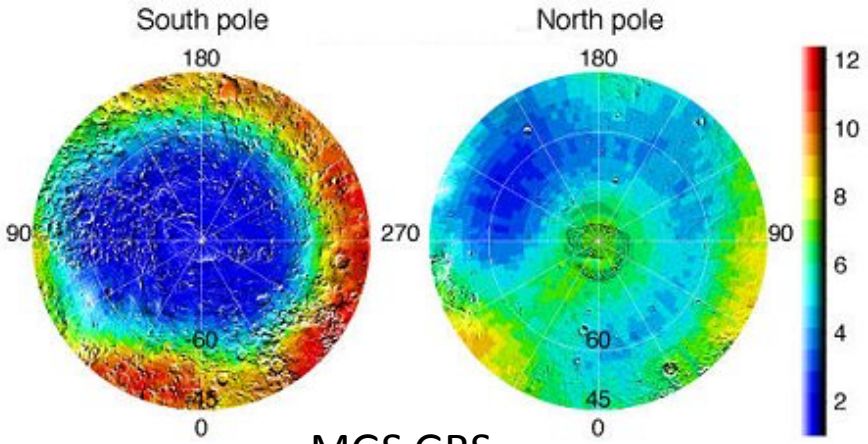


Siegler et al., 2012

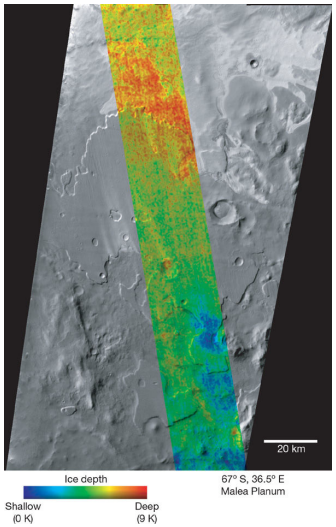

MARS SOUTH POLE APPARENT THERMAL INERTIA
0
90
270
180
-80
-70
-60
0
100
200
300
400
500
600
700
I* (J m-2 sec-1/2 K-1)
MARS SOUTH POLE LAMBERT ALBEDO
0
90
270
180
-80
-70
-60
0.1
0.2
0.3
0.4
0.5
AL







MGS GRS



Bandfield, 2007

Conclusions:

1. SPLD are near-surface high thermal inertia ice
2. SPLD are overlain by ~4 cm of dust

Implications:

1. The surface firn layer on Mars under current climate conditions is < 2mm thick
2. NPLD and SPLD have similar thermophysical properties
3. There may be lots of ~4 cm thick dust layers in the Mars SPLD and NPLD because this is the “natural” depth of polar dust thermal lag deposits