Seasonal Changes in Titan’s Surface Temperatures

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Location of CIRS on Cassini
CIRS
Mechanical Layout
CIRS Fields of Views
CIRS Far-Infrared 15 cm$^{-1}$ Spectra of Titan Variation with Emission Angle

![Graph showing brightness temperature variation with wavenumber for different emission angles, indicating features such as tropopause, N$_2$-N$_2$, N$_2$-CH$_4$, stratosphere, troposphere, and Voyager IRIS.]
CIRS Coverage at 15 cm\(^{-1}\) Resolution

Map of Saturn’s Moon Titan - February 2009

Dec 06 to May 08
Nov 08 to Dec 09
Titan Surface Temperature vs Latitude

CIRS Map of Surface Temperatures
from Cottini et al., PSS, 2011
Diurnal Variation of Surface Temperature
from Cottini et al., PSS, 2011
Temperature Variation with Longitude near Equator (±10°)

12 Apr 2011

GSFC

Xanadu

Belet
Seasonal Surface Temperature dependence on surface material

From Tokano (2005) Icarus 173, 222

12 Apr 2011
Temperature Profile Dependence On Latitude

Altitude (m) vs. Temperature (K) graph showing different profiles for HASI smoothed, 70 N, and 70 S locations.
Altitude dependence of Methane Mole Fraction

From Niemann et al., JGR, 2010

revised from 2005
Haze Opacity Variation with Latitude

Cassini CIRS

Cottini et al., PSS, 2011

Voyager IRIS

Samuelson et al., PSS, 1997

Cassini VIMS

Rannou et al., Icarus 2010
Titan Surface Temperature vs Latitude
Seasonal Variation

12 Apr 2011
Titan Surface Temperature vs Latitude
With Fitted Cosine

Seasonal lag $\Delta L_s = \sim 13^\circ$
Surface Brightness Temperatures from Voyager

$L_s = 10^\circ$

Close to lag

$\Delta L_s = \sim 13^\circ$


Courtin & Kim 2002, PSS 50, 309.
Titan Surface Temperature Seasonal Variation
Comparison with Predictions for Surface Types

Surface types from Tokano 2005, Icarus 173, 222
Surface Physical Properties

From Tokano, Icarus 173, 222 (2005)

<table>
<thead>
<tr>
<th></th>
<th>thermal inertia (I)</th>
<th>albedo (A)</th>
<th>surface drag coeff. (C_D)</th>
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</thead>
<tbody>
<tr>
<td>Porous icy regolith</td>
<td>335</td>
<td>0.38</td>
<td>0.002</td>
</tr>
<tr>
<td>Rock-ice mixture</td>
<td>2711</td>
<td>0.38</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Observations suggest low thermal inertia.
Latitudinal Cloud Distribution

From Rodriguez, Nature 459, 678 (2009)

Map of Titan’s clouds from VIMS
July 2004 to December 2007
Summary

- **2006-08 (Late Northern Winter)** data show a N-S asymmetry:
  South Pole was ~2 K colder than the equator.
  North Pole was ~3 K colder than the equator.
  Temperature distribution was centered at ~10 S.

- **2008-10 (Equinox)** evidence of seasonal temperature shift:
  Comparison of 2008-10 with 2006-08 shows
  ~0.5 K warming in north and ~0.5 K cooling in south.
  Center of temperature distribution moved to 8 S.

- Temperatures correspond to a surface with a low thermal inertia.
- Seasonal lag $\Delta L_s = \sim 13^\circ$ behind insolation, consistent with Voyager.
- Elevated temperature at 65 S coincides with cloud-free zone.