

# MARSTHERM: Thermophysical Analysis Tools for Mars Research

<http://marstherm.boulder.swri.edu>

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## MOTIVATION

Characterizing near-surface properties is essential for assessing landing sites and for understanding geologic processes on Mars. Critical to that effort is the analysis of thermal inertia, a material property derived from temperature data that provides a means to constrain grain size, induration, rock abundance, lateral mixtures of materials, and layering. To enable wider use, we developed a website that provides access to our thermal model, TES products and analysis tools, and software for deriving THEMIS thermal inertia.

## BACKGROUND

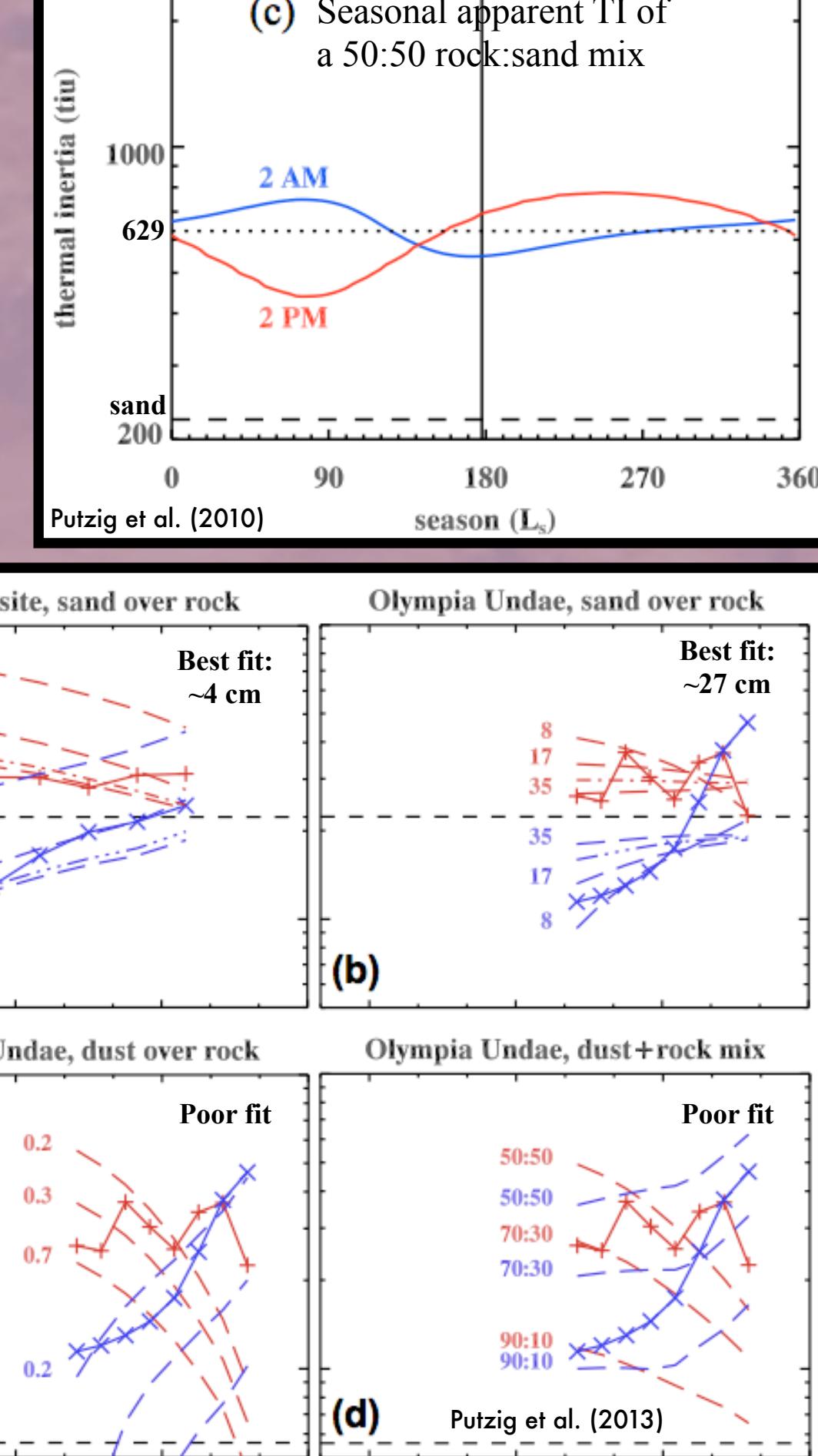
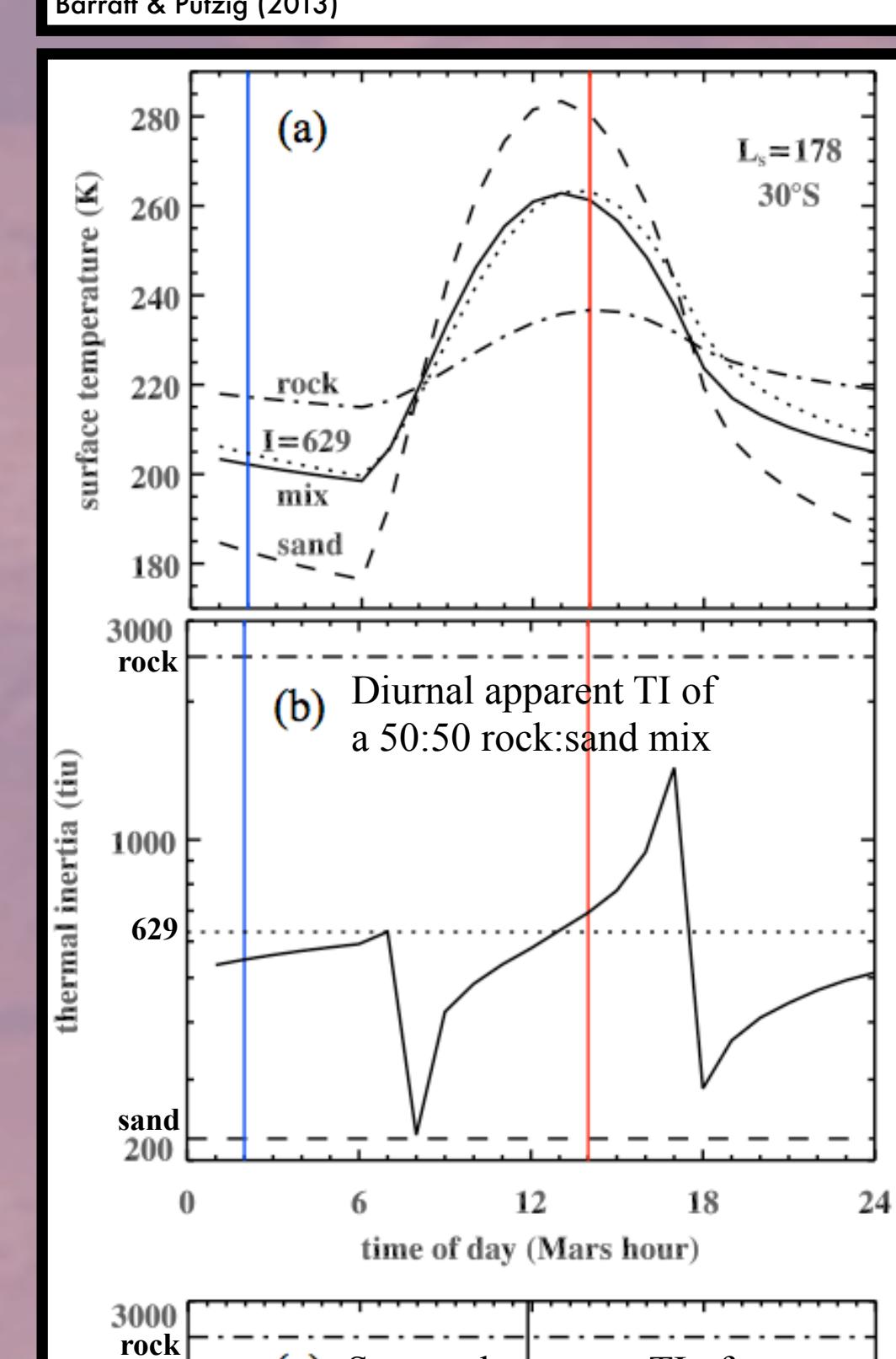
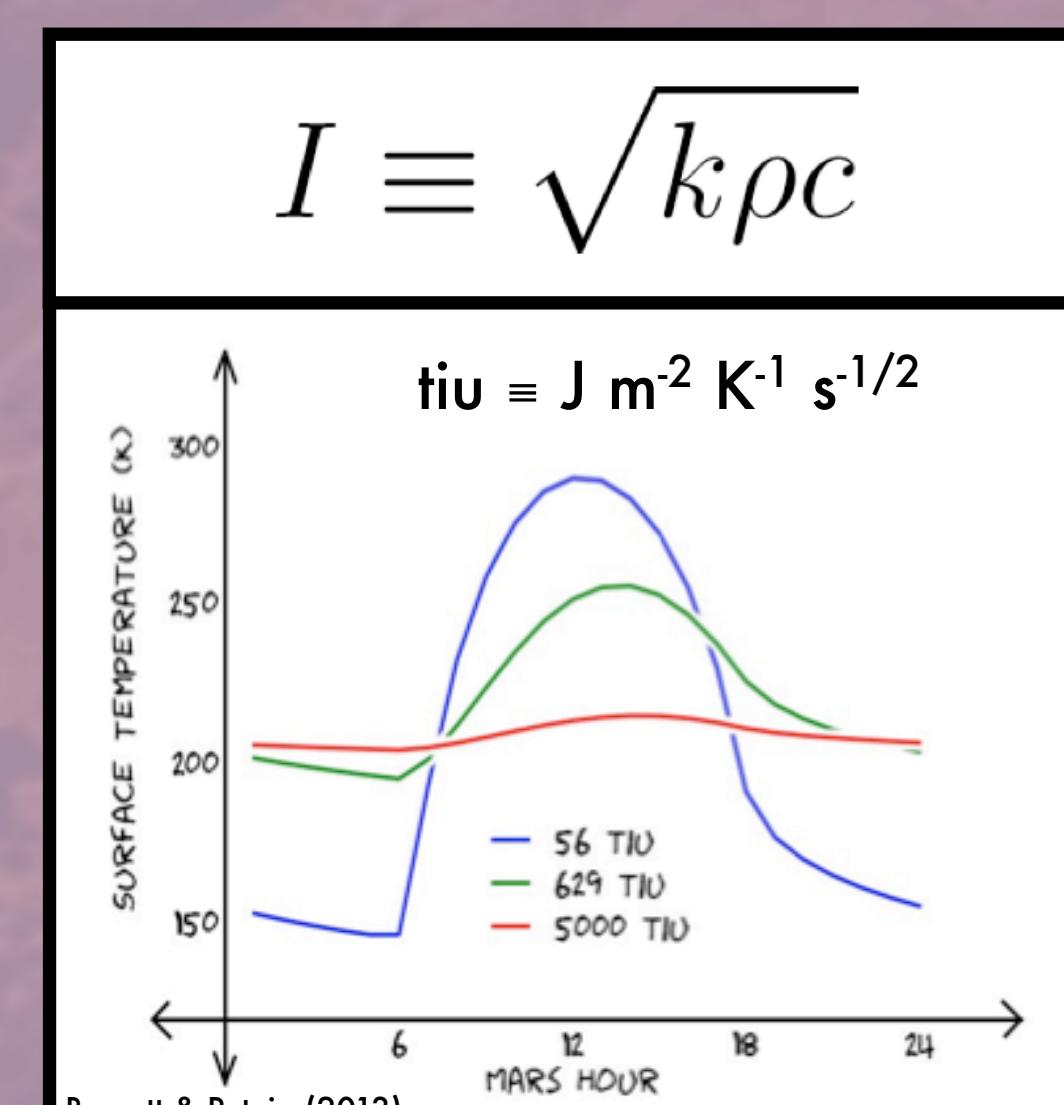
**Thermal Inertia**  
Conductivity, density, and heat capacity make up thermal inertia, which in a planetary context controls how a material stores heat during the day and reradiates it at night.

Modeled temperatures for a broad range of thermal inertia, albedo, and other conditions can be used to derive thermal inertia from temperature observations.

## Heterogeneity

Because temperature varies nonlinearly with thermal inertia, mixtures or layers of materials in an instrument's view will yield different values of apparent thermal inertia.

These effects can be used to constrain physical properties of surfaces, such as the amounts of sand overlying ground ice (with rock-like thermal inertia) at the Phoenix site and in the north polar erg of Mars.



## WEBSITE FEATURES

### User Accounts

**MARSTHERM**  
Thermophysical Analysis Tools For Mars Research

Welcome to MARSTHERM, the home of thermophysical analysis tools developed by Mars researchers at the Southwest Research Institute in Boulder, Colorado.

If you are a first-time user, please [register](#) for a free account.

**MARSTHERM**  
Thermophysical Analysis Tools For Mars Research

You have 0 thermal model runs and 0 THEMIS images from 0 projects.

[Run the Thermal Model](#)

**User Profile**

Welcome, Joseph  
Full name: joe  
Institution: Academie des Sciences  
E-mail address: j...@boulder.swri.edu  
Phone Number: 720-240-0130  
Comments:  
Registered since: 2013-12-02 14:35:41  
Account History: 2013-12-02 14:35:41 Application received  
2013-12-02 14:36:41 Application accepted by than  
2013-12-02 14:51:16 instant change to Academie des Sciences by joe

Home page shows usage summary and user profile.

### Online Documentation

#### MARSTHERM Thermal Model

**Projects Documentation**

- Introduction
- Theory
- Standard Thermal Model
- Atmospheric Model
- Users Guide
- Program Flow
- Inputs
- Hard Wired Parameters
- Output
- Research
- Plotted Output
- Uncertainties

**THEMIS Processing**

- Introduction
- Theory
- User Guide
- Quality Ratios
- Output
- Albedo
- Thermal Inertia
- Output Files Description
- Output Files Description HDF5
- Reading hdf5 files with python
- Reading hdf5 files with idl
- Reading hdf5 files with matlab

#### Introduction

MARSTHERM is a Mars surface thermal model developed and modified for use in the determination of the thermal inertia of the Martian surface from MGS TES temperature data. For a given set of thermophysical parameters (thermal inertia, albedo, dust opacity, etc.) the model calculates the surface temperature of a location on Mars, as a function of the time. The calculated surface temperatures are then compared to observed temperatures to find the thermal inertia. This model was used as the basis for calculating Mars thermal inertia as presented by Mellon et al. (2000), Putzig et al. (2005), and Putzig and Mellon (2007).

### Global Maps

**MARSTHERM**  
Thermophysical Analysis Tools For Mars Research

**Mars Global Maps**

Seasonal thermal inertia derived from Thermal Emission Spectrometer (TES) bolometer observations (Putzig and Mellon, 2007). Maps are binned at 20 pixels per degree in seasonal increments of 10 degrees of solar longitude ( $L_s$ ) for dayside and nightside observations.

(a) Phoenix site, sand over rock  
(b) Olympia Undae, sand over rock  
(c) Olympia Undae, dust over rock  
(d) Olympia Undae, dust+rock mix

## Thermal Modeling

**MARSTHERM**  
Thermophysical Analysis Tools For Mars Research

**MARSTHERM Thermal Model**

Your Runs | New Runs | Documentation

Type 'help' in any field and click 'Submit' for guidance.

Thermal Inertia ( $J/m^2 K s^{1/2}$ ): 250.0  
Preset Thermal Inertia/Albedo Value: 250.0  
Effective Semi-Infinite  $CO_2$  (kg/m<sup>2</sup>): 6.0  
Surface Pressure (mb): 6.0  
Atmospheric Dust Opacity: 0.1  
Lowest (Southern Most) Latitude: 0.0  
Latitudes Per Run: 1  
Latitude Increment: 5.0  
Mode: Diurnal  
Solar Longitude (season) [DEG]: 180.0  
Print Last Day: NA  
Print Type: Production

Model Output: Run 31  
Plot previews

Model Output: Run 32  
Plot previews

## GALE CRATER CASE STUDY

Barratt (2013) used MARSTHERM to study thermophysical properties within Gale crater, site of the MSL Curiosity rover.

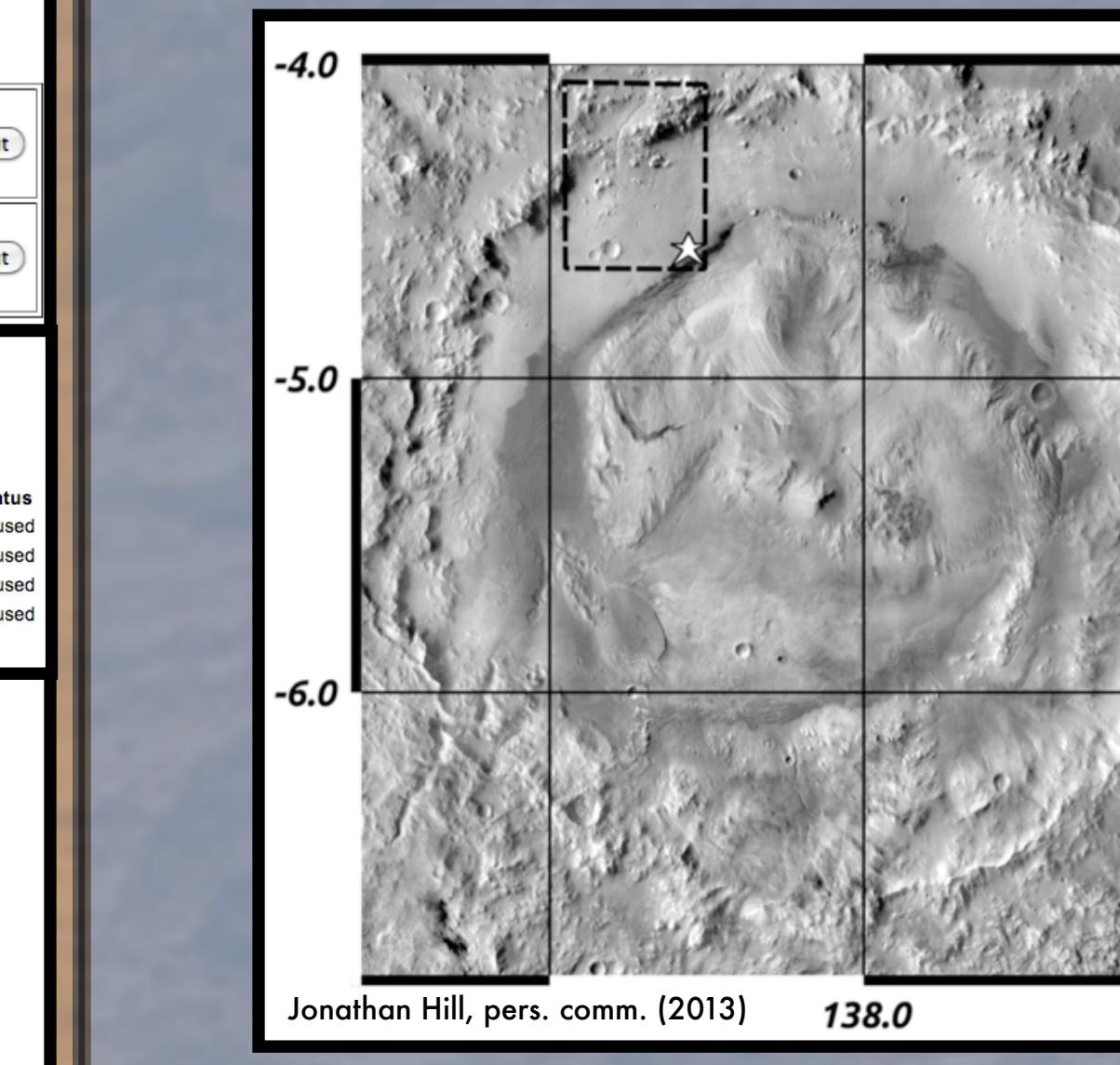


Fig. 1: Gale crater in a THEMIS-visible mosaic. Dashed box: Fig. 3. Star: MSL.

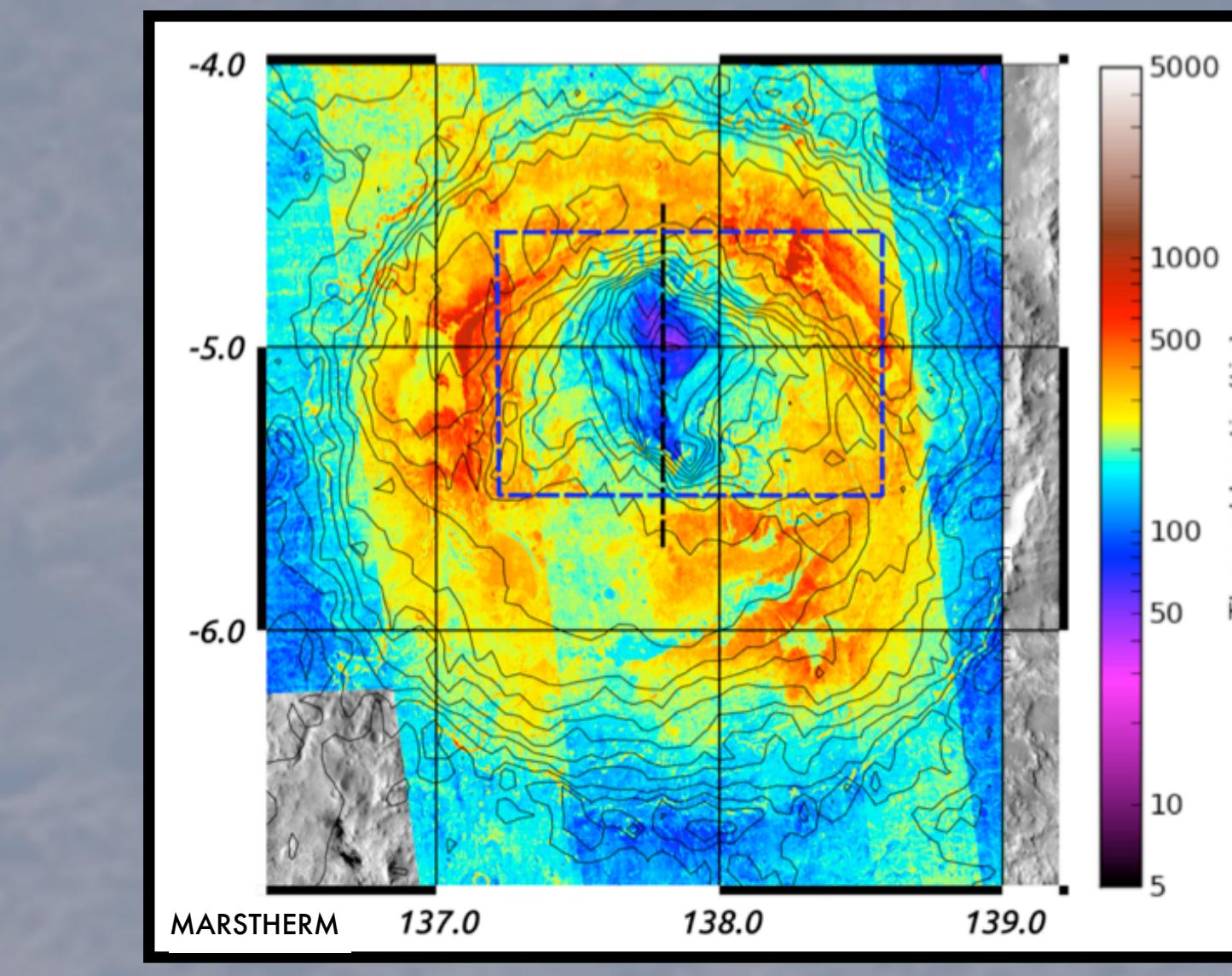


Fig. 2: Thermal inertia of Gale in a mosaic of results from THEMIS-IR nighttime images.

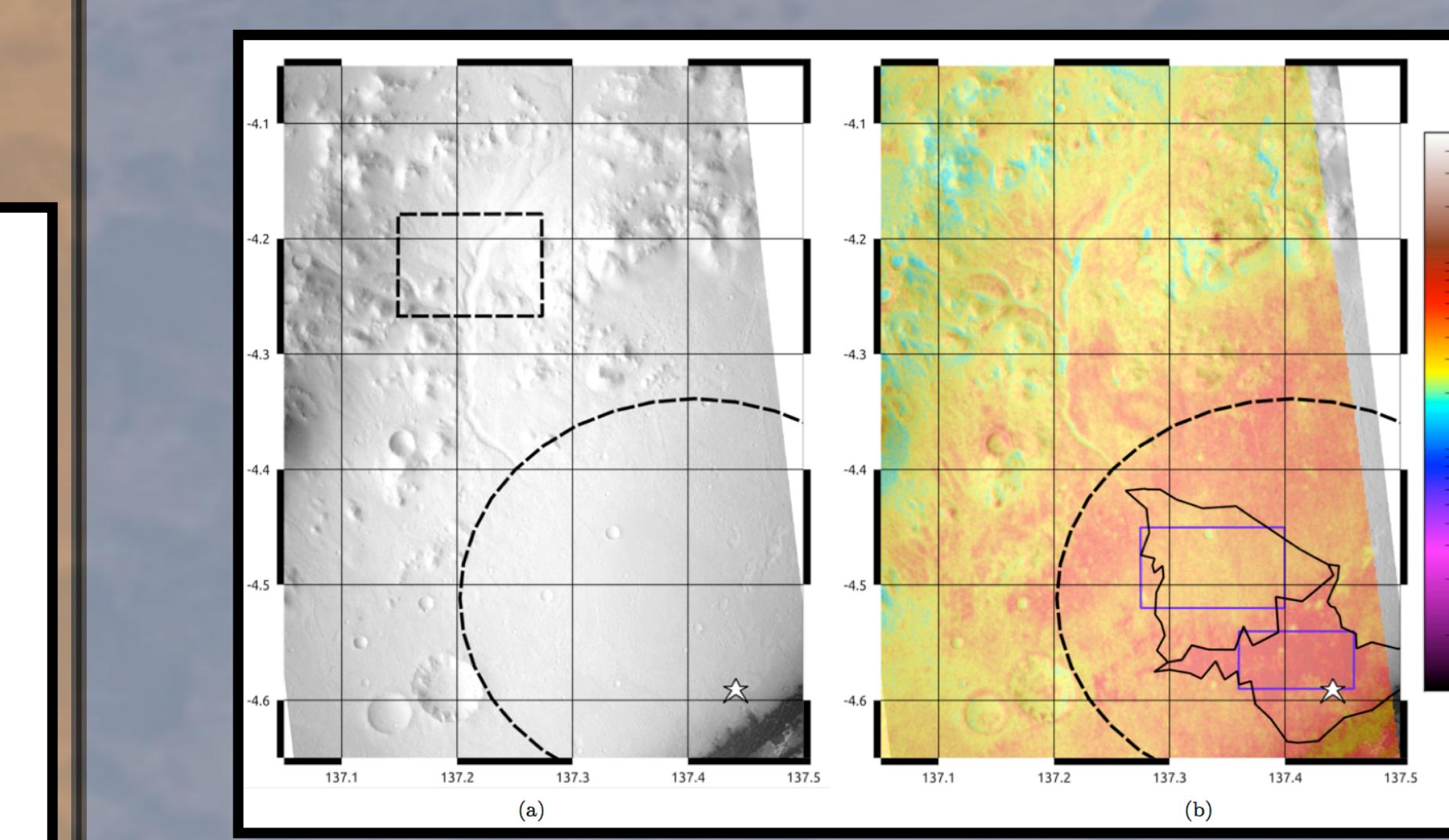


Fig. 3: Peace Vallis in (a) CTX imagery and (b) THEMIS thermal inertia (image I18262008). Dashed line and star show MSL landing ellipse and location. Thin solid outlines show Low and High Thermal Inertia Fan units.

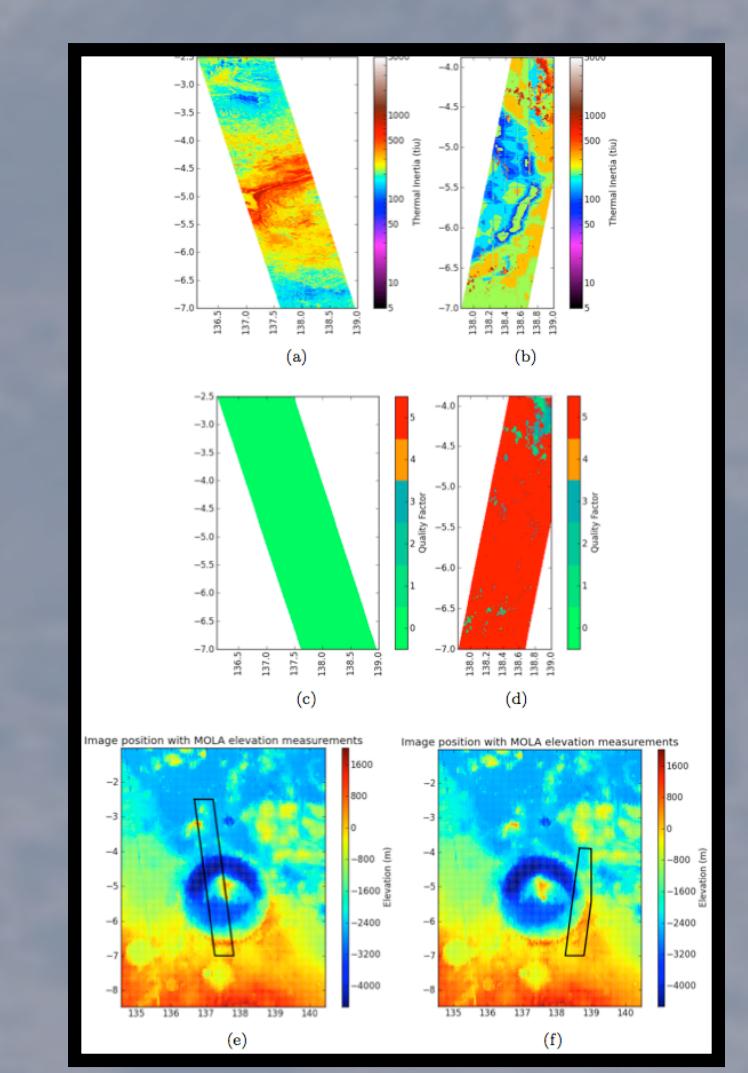


Fig. 4: Thermal inertia, quality, and context for two THEMIS images in Gale MARSTHERM project.

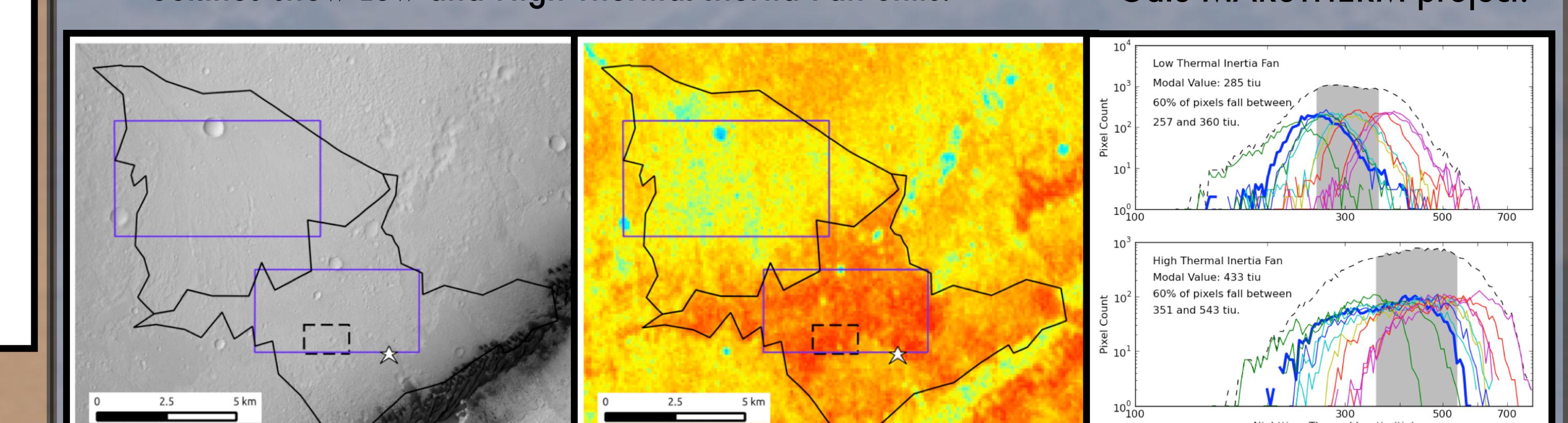


Fig. 5: Outlines show Low and High Thermal Inertia Fan units in (left) CTX imagery and (center) THEMIS thermal inertia (image I01350002). Purple boxes are areas used for histograms at right, which show values for 11 THEMIS images. Thick blue lines correspond to image at center, dashed line is histogram for all images. Gray bars delineate 60% of pixel values for all images.

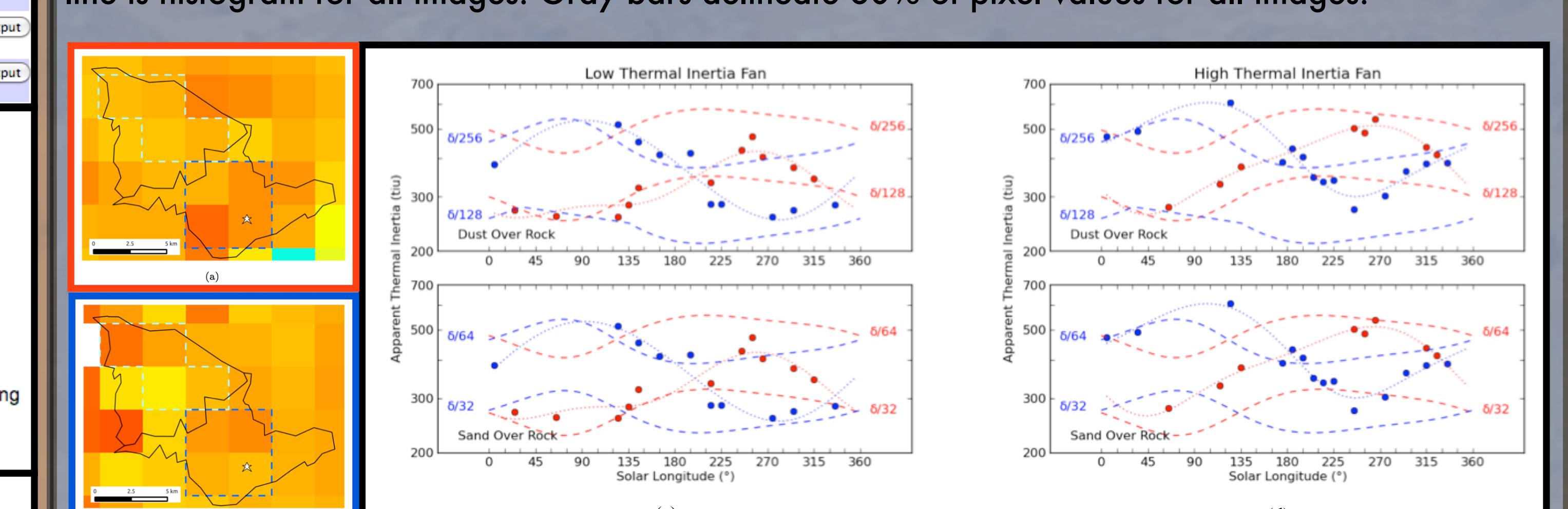


Fig. 6: TES thermal inertia in the Peace Vallis fan compared to two-component model results. Annual-median maps show (a) dayside and (b) nightside values, with dashed outlines of pixels used in seasonal analysis for the Low (c) and High (d) Thermal Inertia Fan units. TES seasonal dayside (red dots) and nightside (blue dots) values are fit with second-order harmonics (dotted lines) and compared to apparent thermal inertia derived from layered models (dashed lines) with differing thicknesses of dust or sand overlying rock (seasonal skin depth  $\delta$  is 20 cm for dust, 70 cm for sand).

**Conclusions:** THEMIS results show distinct variations in apparent thermal inertia consistent with TES results, at higher resolution. TES seasonal variations in apparent thermal inertia indicate a layered structure with either dust or sand overlying bedrock.