images and greatly speeds the overall calibration process. ACAL consists of three modules:

1. ACALDOTS — the primary module — takes calibration target images, locates and measures the 2D locations of the target's fiducial marks and then synthesizes their corresponding 3D locations based on knowledge of the calibration target's geometry and its 3D location. ACALDOTS handles uneven lighting, large-scale variations due to range differences, and barrel distortion effects of the type found in wide-angle lenses. It understands both planar and corner-cube (i.e., 3D) calibration target geometries.

2. ACALINFO takes the calibration data produced by ACALDOTS and estimates an initial 3D position and orientation (i.e., camera pose) for the camera to seed the estimation of the remaining camera model parameters.

3. ACALFIX takes the original calibration data and the camera model produced from it and generates a refined set of calibration data by removing localization errors in the 2D fiducial mark positions introduced by perspective foreshortening caused by the calibration target's orientation and geometry.

The automation in ACAL is robust enough that under even extreme image conditions, the required input from the user averages to no more than about one mouse click per target fixture.
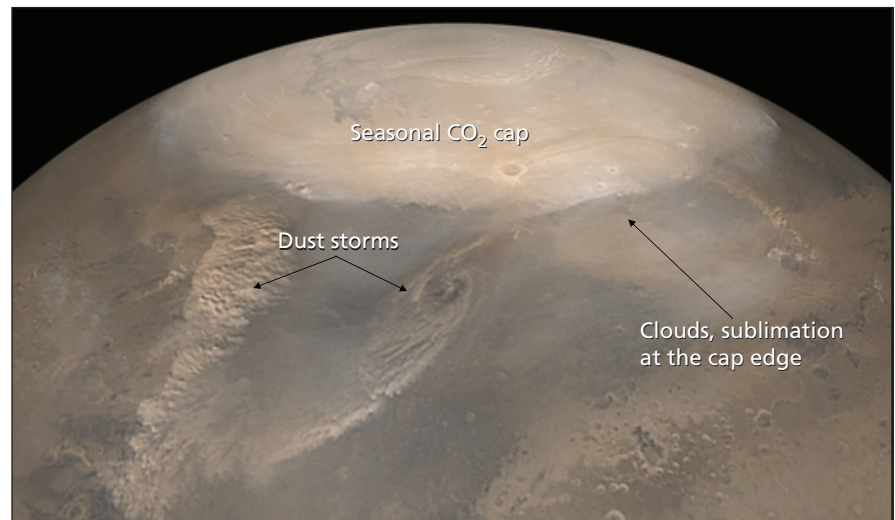
# Tracking the Martian $CO_2$ Polar Ice Caps in Infrared Images

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Researchers at NASA's Jet Propulsion Laboratory have developed a method for automatically tracking the polar caps on Mars as they advance and recede each year (see figure). The seasonal Mars polar caps are composed mainly of $CO_2$ ice and are therefore cold enough to stand out clearly in infrared data collected by the Thermal Emission Imaging System (THEMIS) onboard the Mars Odyssey spacecraft. The Bimodal Image Temperature (BIT) histogram analysis algorithm analyzes raw, uncalibrated data to identify images that contain both "cold" ("polar cap") and "warm" ("not polar cap") pixels. The algorithm dynamically identifies the temperature that separates these two regions. This flexibility is critical, because in the absence of any calibration, the threshold temperature can vary significantly from image to image. Using the identified threshold, the algorithm classifies each pixel in the image as "polar cap" or "not polar cap," then identifies the image row that contains the spatial transition from "polar cap" to "not polar cap." While this method is useful for analyzing data that has already been returned by THEMIS, it has even more significance with respect to data that has not yet been collected. Instead of seeking the polar cap only in specific, targeted images, the simplicity and efficiency of this method makes it feasible for direct, onboard use. That is, THEMIS could continuously monitor its observations for any detections of the polar-cap edge, producing detections over a wide range of spatial and temporal conditions. This effort can greatly contribute to our understanding of long-term climatic change on Mars.



**Recession of the Seasonal $CO_2$ Cap** is shown for Northern Martian Spring.

# Processing TES Level-2 Data

*NASA's Jet Propulsion Laboratory, Pasadena, California*

TES Level 2 Subsystem is a set of computer programs that performs functions complementary to those of the program summarized in the immediately preceding article. TES Level-2 data pertain to retrieved species (or temperature) profiles, and errors thereof. Geolocation, quality, and other data (e.g., surface characteristics for nadir observations) are also included. The subsystem processes gridded meteorological information and extracts parameters that can be interpolated to

the appropriate latitude, longitude, and pressure level based on the date and time. Radiances are simulated using the aforementioned meteorological information for initial guesses, and spectroscopic-parameter tables are generated. At each step of the retrieval, a nonlinear-least-squares-solving routine is run over multiple iterations, retrieving a subset of atmospheric constituents, and error analysis is performed. Scientific TES Level-2 data products are written in a format known as Hierarchical Data Format Earth Observing System 5 (HDF-EOS 5) for public distribution.

# ⚙ SmaggIce Version 1.8

*John H. Glenn Research Center, Cleveland, Ohio*

SmaggIce version 1.8 is a set of software tools for geometrical modeling of, and generation of grids that conform to, both clean and iced airfoils. A prior version (SmaggIce 1.2) was described in "Preparing and Analyzing Iced Airfoils" (LEW-17399), *NASA Tech Briefs*, Vol. 28, No. 8 (August 2004), page 32. Ice shapes, especially those that include rough surfaces, pose difficulty in generating high-quality grids that are essential for predicting airflows by use of computational fluid dynamics. SmaggIce version 1.8 contains software tools needed to overcome this difficulty. For a given airfoil, it allows the user to define the flow domain, decompose the domain into blocks, generate grids, merge gridded blocks, and control the density and smoothness of each grid. Among the unique features of version 1.8 is a thin C-shaped block, called a "viscous sublayer block," which is wrapped around an iced airfoil and its wake line and serves as a means to generate highly controlled grids near the rough ice surface. Users can modify block boundary shapes using control points of non-uniform rational B-spline (NURBS) curves. Concave ice regions can be smoothed during geometrical modeling or creation of the viscous sublayer block.