# Real-Time Detection of Dust Devils From Pressure Readings

**Dust devils are identified as large deviations from a sliding polynomial fit.**

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

A method for real-time detection of dust devils at a given location is based on identifying the abrupt, temporary decreases in atmospheric pressure that are characteristic of dust devils as they travel through that location. The method was conceived for use in a study of dust devils on the Martian surface, where bandwidth limitations encourage the transmission of only those blocks of data that are most likely to contain information about features of interest, such as dust devils. The method, which is a form of intelligent data compression, could readily be adapted to use for the same purpose in scientific investigation of dust devils on Earth.

In this method, the readings of an atmospheric-pressure sensor are repeatedly digitized, recorded, and processed by an algorithm that looks for extreme deviations from a continually updated model of the current pressure environment. The question in formulating the algorithm is how to model current "normal" observations and what minimum magnitude deviation can be considered sufficiently anomalous as to indicate the presence of a dust devil. There is no single, simple answer to this question: any answer necessarily entails a compromise between false detections and misses.

For the original Mars application, the answer was sought through analysis of sliding time windows of digitized pressure readings. Windows of 5-, 10-, and 15-minute durations were considered. The windows were advanced in increments of 30 seconds. Increments of other sizes can also be used, but computational cost increases as the increment
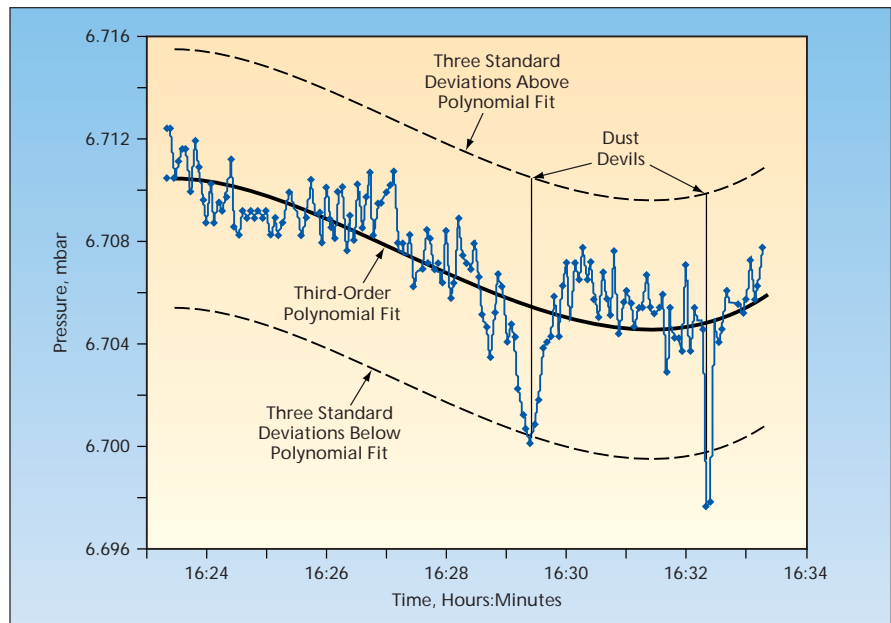


A **Third-Order Polynomial Fit** with 3-standard-deviation limits was superimposed on a 10-minute sliding time window of Mars atmospheric-pressure readings. Two dust devils were detected as negative deviations of more than 3 standard deviations.

decreases and analysis is performed more frequently. Pressure models were defined using a polynomial fit to the data within the windows. For example, the figure depicts pressure readings from a 10-minute window wherein the model was defined by a third-degree polynomial fit to the readings and dust devils were identified as negative deviations larger than both 3 standard deviations (from the mean) and 0.05 mbar in magnitude. An algorithm embodying the detection scheme of this example was found to yield a miss rate of just 8 percent and a false-detection rate of 57

percent when evaluated on historical pressure-sensor data collected by the Mars Pathfinder lander. Since dust devils occur infrequently over the course of a mission, prioritizing observations that contain successful detections could greatly conserve bandwidth allocated to a given mission. This technique can be used on future Mars landers and rovers, such as Mars Phoenix and the Mars Science Laboratory.

*This work was done by Kiri Wagstaff of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-44724*

# Determining Surface Roughness in Urban Areas Using Lidar Data

**An automatic derivation of relevant parameters estimates surface roughness.**

*Stennis Space Center, Mississippi*

An automated procedure has been developed to derive relevant factors, which can increase the ability to produce objective, repeatable methods for determining aerodynamic surface roughness. Aerodynamic surface roughness is used for many applications, like

atmospheric dispersive models and wind-damage models. For this technique, existing lidar data was used that was originally collected for terrain analysis, and demonstrated that surface roughness values can be automatically derived, and then subsequently utilized

in disaster-management and homeland-security models.

The developed lidar-processing algorithm effectively distinguishes buildings from trees and characterizes their size, density, orientation, and spacing (see figure); all of these variables are param-

**Processed Lidar Data** (left) and **Aerial Imagery** (right) show a one-square-kilometer area of Broward County, Florida.

eters that are required to calculate the estimated surface roughness for a specified area. By using this algorithm, aerodynamic surface roughness values in urban areas can then be extracted automatically. The user can also adjust the algorithm for local conditions and lidar characteristics, like summer/winter vegetation and dense/sparse lidar point spacing. Additionally, the user can also survey variations in surface roughness that occurs due to wind direction; for example, during a hurricane, when wind direction can change dramatically, this variable can be extremely significant.

In its current state, the algorithm calculates an estimated surface roughness for a square kilometer area; techniques using the lidar data to calculate the surface roughness for a "point," whereby only roughness elements that are upstream from the point of interest are used and the wind direction is a vital concern, are being investigated. This technological advancement will improve the reliability and accuracy of models that use and incorporate surface roughness.

# DSN Data Visualization Suite

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

The DSN Data Visualization Suite is a set of computer programs and reusable Application Programming Interfaces (APIs) that assist in the visualization and analysis of Deep Space Network (DSN) spacecraft-tracking data, which can include predicted and actual values of downlink frequencies, uplink frequencies, and antenna-pointing angles in various formats that can include tables of values and polynomial coefficients. The data can also include lists of antenna-pointing events, lists of antenna-limit events, and schedules of tracking activities.

To date, analysis and correlation of these intricately related data before and after tracking have been difficult and time-consuming. The DSN Data Visualization Suite enables operators to quickly diagnose tracking-data problems before, during, and after tracking. The Suite provides interpolation on demand and plotting of DSN tracking data, correlation of all data on a given temporal point, and display of data with color coding configurable by users. The suite thereby enables rapid analysis of the data prior to transmission of the data to DSN control centers. At the control centers, the same suite enables operators to validate the data before committing the data to DSN subsystems. This software is also Web-enabled to afford its capabilities to international space agencies.