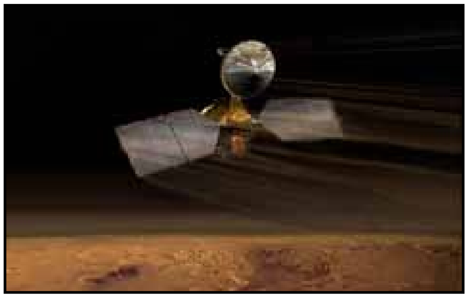
The Winds of Mars

The Mars Reconnaissance Orbiter (MRO) was launched from Cape Canaveral on 12 August 2005, and has been in a 112-minute polar orbit since November of 2006.



Its mission:

- to characterize the present climate of Mars and its physical mechanisms of seasonal and interannual climate change
- to determine the nature of complex layered terrain on Mars and identify water-related landforms
- to search for sites showing evidence of aqueous and/or hydrothermal activity
- to identify and characterize sites with the highest potential for landed science and sample return by future Mars missions
- and to return scientific data from Mars landed craft during a relay phase.

The MRO's instrument is the Mars Color Imager (MARCI), a charge-coupled device (CCD) camera using seven different filters. MARCI has two all-refractive 180° 'fisheye' lenses, one optimized for the visible and near-IR and one for the UV bands. The beams from these two lenses are brought to the CCD through a prism. A color filter array with seven different bandpasses (five visible/near-IR and two UV) is directly bonded to the CCD.

A typical image consists of seven 'framelets', each 1024 pixels wide and 16 pixels high, in each of these bandpasses. The visible resolution from 300 km is about 1 km/pixel at nadir.

The data, processed by the Malin Space Science Systems (MSSS), produce daily color composites depicting the clouds on Mars.

In May 2009, NASA funded our proposal to track cloud features over the north polar region where clouds form during the Martian summer. The water ice clouds form due to sublimation of the ice from the polar cap.

MSSS provided one summer season of blue and red filter images, reprojected over the north pole. The blue filter is best for water ice clouds; the red filter is sensitive to dust.

In order to track the clouds, time sequences of images are used. These time animations revealed a distortion in the images that prevented us from tracking clouds: not only did the clouds move, so did the surface features!

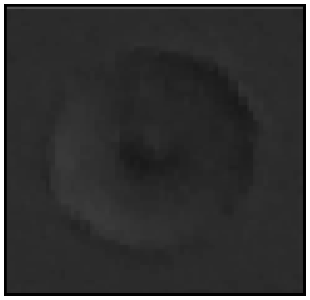
In order to correct for the geometric distortion landmarks were found, templates were extracted, and offsets were determined using McIDAS software, developed here at SSEC. The landmarks were surface ice features or high-contrast craters.

Color composite. Clouds appear as bluish-white features.

Many landmarks were extracted manually from the images, when there was little distortion; that is, when the feature is near nadir (viewed directly below the satellite). Also, good distribution of landmarks over the polar region was required.

Each landmark was then matched (using a cross correlation technique) to all other images in one month of data. Only highly correlated matches are saved. This discards matches of features that are partially obscured (clouds or dust) or too far from nadir.

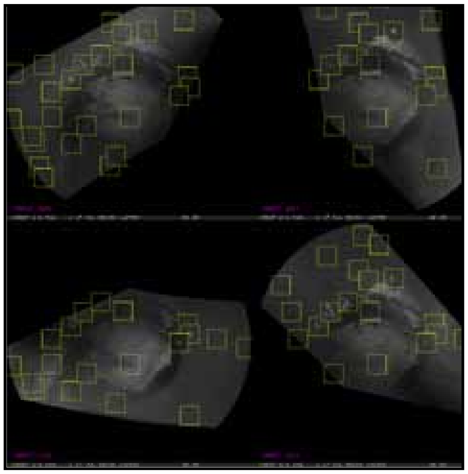
The matching resulted in offsets that could be used by MSSS to reprocess the images. This resulted in corrected



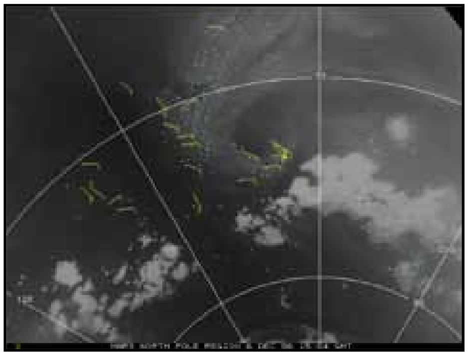
Example landmarks: Crater (left) and a surface ice feature (right).

images where the surface features did not move. Due to the nature of the distortion and camera geometry, this technique worked well for the red filter images; but not for the blue filter images.

Cloud Tracking Methodology is based on code used to derive feature-tracked winds for both geostationary and polar orbiting Earth-based satellite data. This is done by identifying cloud features, or targets, (based on gradients in the image) and then locating (using a cross correlation technique) the feature in images at different times. The speed of the wind can be inferred, based on the displacement of the feature.



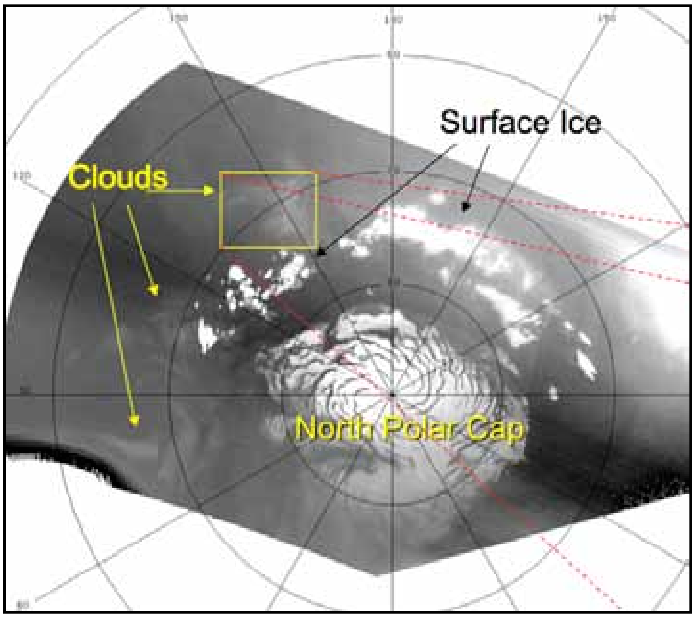
Distribution of landmark locations.



Targets are the cyan dots; winds are yellow flags.

Because the clouds are so thin, surface features interfere with the automated cloud tracking. Therefore, we had to manually track clouds and also manually edit the winds to ensure the winds were correct.

The 'high' density winds dataset retrieved from the north polar region of Mars will be used as input to global models and could lend insight into behavior and life cycle of baroclinic waves and cyclones on the planet.



View from pole to 60º north latitude. The polar ice cap is in the center. The bright white features in the upper left are surface ice. The wispy-like features are clouds.

Current status:

While the manual and automated tracking is complete, as is the quality control of the winds, we are beginning the analysis of the data, along with comparisons to numerical models (from the University of Maryland). Sanjay Limaye and Scott Lindstrom of SSEC are using GPS data to infer the heights of the clouds.

Emily Sorensen, an undergraduate Engineering student who graduated in December 2011, worked on all aspects of the project, from measuring landmarks and determining the distortion, to tracking and quality control of the cloud-tracked motions.

Dave Santek

McIDAS-generated image.