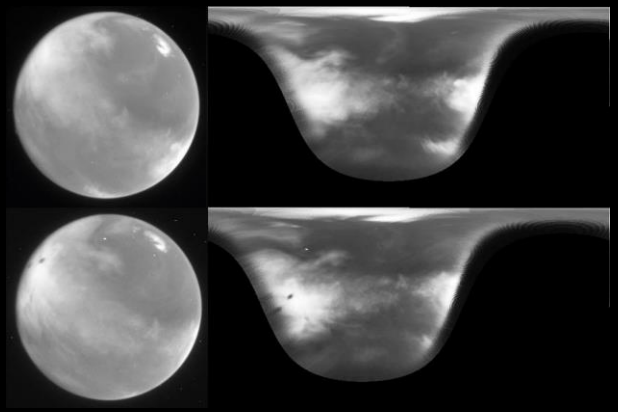
Attempting to Measure Martian Winds Using the Mars Express Visual Monitoring Camera

(with disappointing initial results, but signs that further work may be beneficial)



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Introduction

The few surface level landers on Mars cannot give a view of Martian wind that is even close to comprehensive. Our current methods of understanding Martian wind include using heavily modified models of our own atmosphere, and inferences from temperature profiles. This project attempted to analyse images from the Mars Express Visual Monitoring Camera (VMC) to track clouds and dust storms over time, and hence to estimate wind speeds.

Background

Using satellites for cloud tracking as a proxy for wind speed is a key part of terrestrial weather monitoring and forecasting. Cloud tracking on Mars has been attempted before by Mischna et al. (1998) using three images from the Hubble Space Telescope. Though mostly used for public relations as the “Mars Webcam”, the VMC provides an archive of thousands of images with comparable quality. An automated technique was developed to try and track clouds.

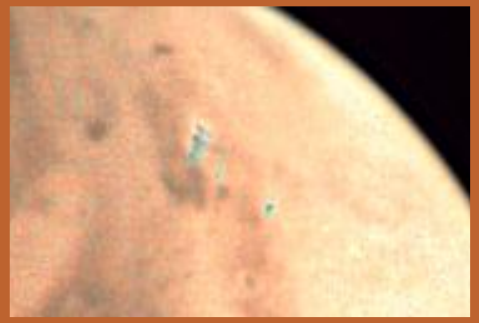
Image Pre-Processing and Projection

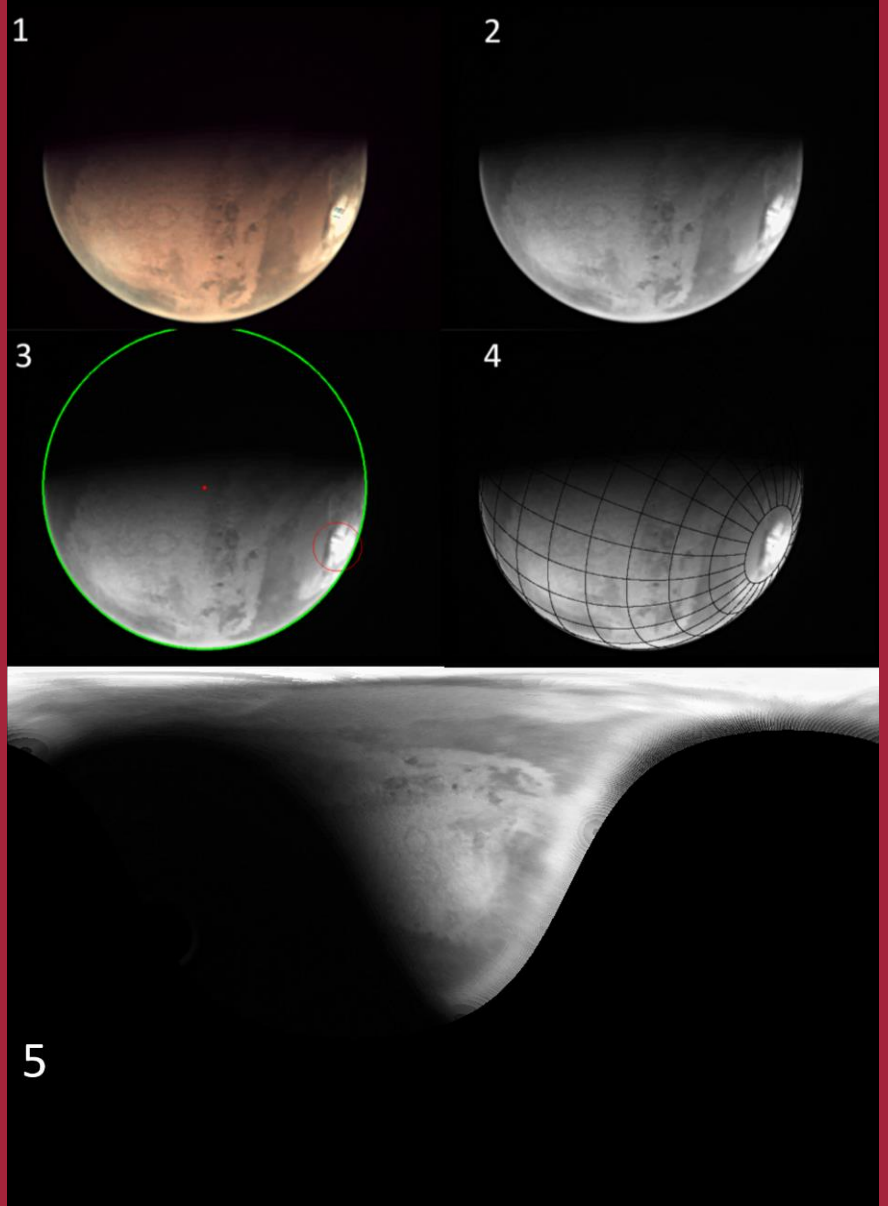
1. Original Images

The original images taken by the VMC are 640 x 480 pixels. They are taken frequently but irregularly, when time permits.

2. Colour and Artifact Removal

Many image processing techniques work more efficiently (or only work) on black and white images. Over time the camera has become degraded, leaving artifacts. These were filtered out.





3. Planetary Disk and Pole Detection

The planetary disks and the locations of either the North or South Pole were detected. Many images were unsuitable for this type of processing.

4. Assigning Latitude and Longitude

The circles from the photographs were converted to spheres, with latitude and longitude assigned from the pole locations.

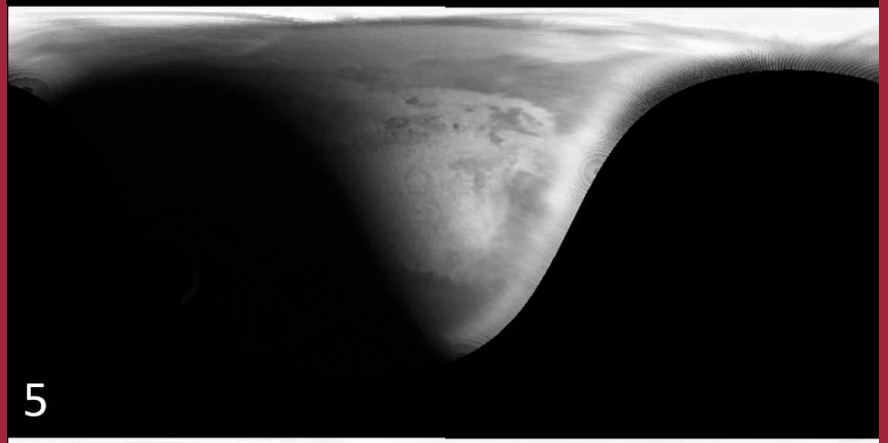
5. Projection

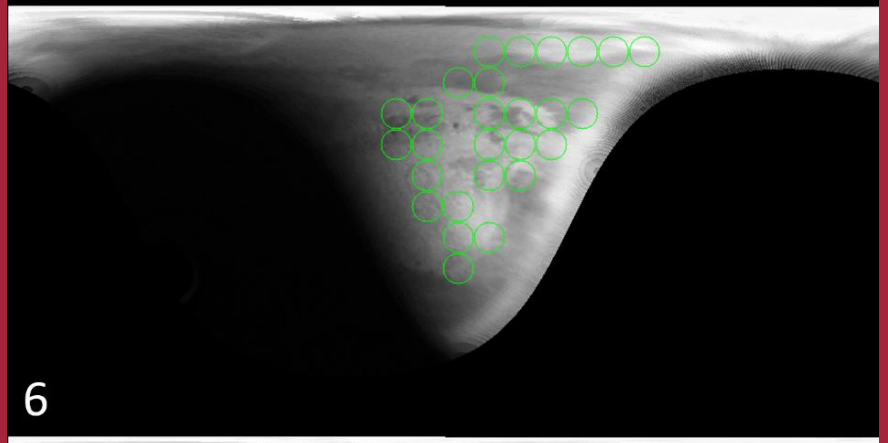
To compensate for changes in camera position between images, they were projected to a uniform flat map.

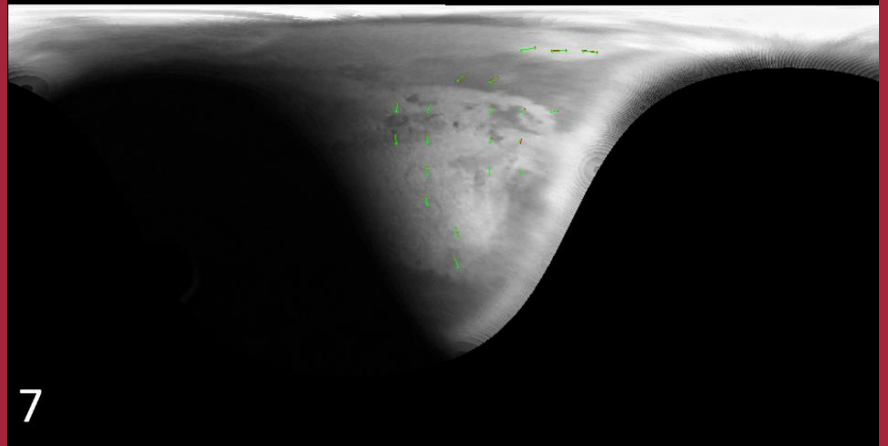
Cloud Tracking

6. Feature Extraction

The images were divided into grids of 32 x 32 pixel boxes, and for each box the standard deviation was measured. Boxes with low standard deviation would be bland and impossible to track with any accuracy, unlike those with high standard deviation which were likely to have unique patterns caused by clouds, dust storms, or surface features like mountains and craters. The locations with low variance and those in the dark areas of the map were discarded

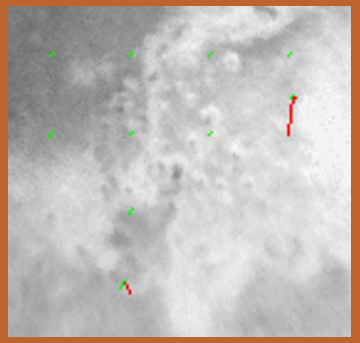






7. Feature Tracking

The identified features were tracked by measuring cross-correlation to find the most similar area in the subsequent image. The process was then performed in reverse. Below, green shows the first tracking, and red where the reverse did not match i.e. weak tracking.

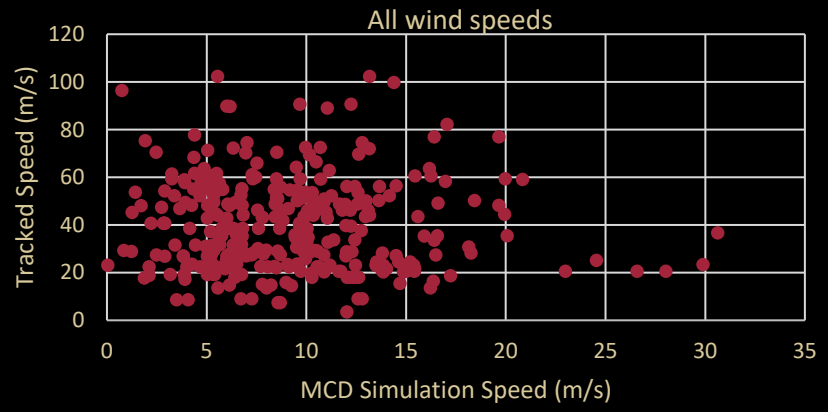


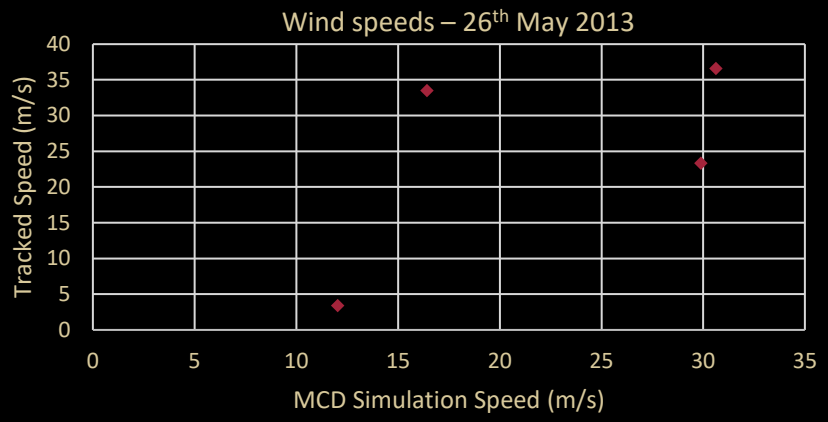
The movement between each reliable pair of locations was used to calculate wind speeds.

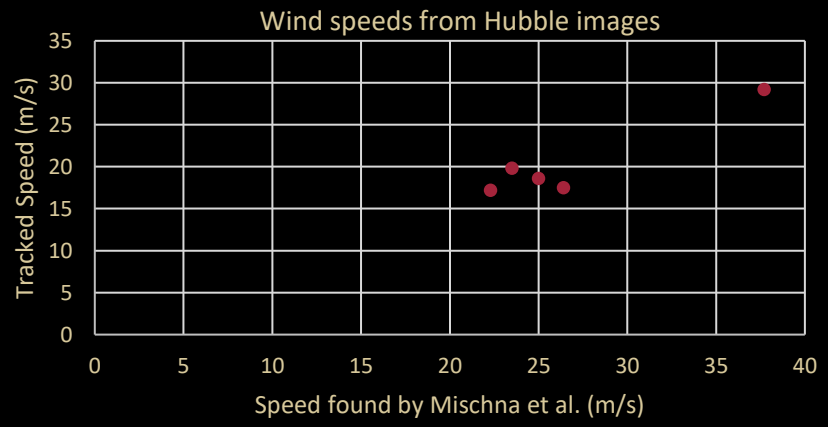
Results and Conclusion

Results

The analysis was carried out on 20 pairs of images from the VMC archive, giving a total of 319 measurements. These were compared to data from the Mars Climate Database, a leading Martian climate model, and were found to have little correlation. A number of factors probably contribute: the images' low resolution combined with an average time difference of only 22 minutes, and difficulty of precisely aligning projected images, means large scope for errors that are quickly magnified.







Conclusion

Despite the poor overall results, the data from a pair of images from 26th May 2013, taken 2 hours apart, are significantly more realistic though still inconclusive. Analysis of Hubble images taken hours apart also produced similar results to those obtained by Mischna et al. (1998). A project currently being undertaken at the University of the Basque Country to process the VMC archive may help improve future work of this nature.

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