EPSC Abstracts
Vol. 7 EPSC2012-439 2012
European Planetary Science Congress 2012

A New Population Dataset on Dust Devil Pressure Drops : Setting the Stage for Mars Science Laboratory

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Abstract

A quarter of a century ago in the first in-situ study of dust devils on Mars, Ryan and Lucich (1983) rue that 'Unfortunately, we have been unable to find a terrestrial data set that permits a one-to-one comparison with our Mars data'. Remarkably, this state of affairs has largely persisted. Here I present a set of fixed station terrestrial field data, enabled by recent technological developments, which enables a direct comparison with dust devils (as indicated by vortex pressure drops) from Mars Pathfinder, Phoenix, and hopefully MSL Curiosity.

Introduction

Dust devils are widely-observed on Mars and in terrestrial arid regions. As with other phenomena, there are many more small ones than there are big ones - the size distribution (i.e. optical diameter) is strongly skewed [1,2,3,4] and may be described by power law, exponential or other functions.

Another relatively easily-measured property is the pressure drop associated with the devil : these appear to follow a power law [5]. Note that the amplitude of the recorded drop may be smaller in magnitude than the pressure drop in the center of the vortex, such that the recorded . However, assuming no bias in miss distances, this can be ignored in direct comparisons. Good records of pressure drops of some 79 vortex encounters were measured by Pathfinder over 83 sols [6] and by Phoenix (504 encounters over 150 sols [8]). The different frequency may in part due to locality (lower insolation at the high latitude Phoenix site and different dust availability) , season. Part is also due to the lower detection threshold in the Phoenix study (30 mbar vs 50 mbar). This latter factor is readily exposed by plotting (figure 1) the encounter rate as a function of pressure drop - it is seen that the data from the two sites collapse onto essentially the same curve.

Unfortunately, systematic datasets on dust devil pressure drops on Earth are not available, with the exception of a single (nearly 50 year-old) study, with only 21 events at White Sands [8,9]. These data too are shown on the same axes on figure 1. The poor counting statistics preclude assessment of whether the data are formally incompatible with the -2 power law that seems to describe the Mars data : the apparent shallower slope may be due to sampling bias (e.g. only starting the chart recorders when a large devil was observed). It is quite clear that the frequency measured here for a given normalized pressure drop (ΔP/P, which in a Rankine vortex is roughly proportional to V^2) is much lower. But is this a result of low detection efficiency, or are terrestrial dust devils simply weaker or less numerous? New field data are needed to answer these questions.

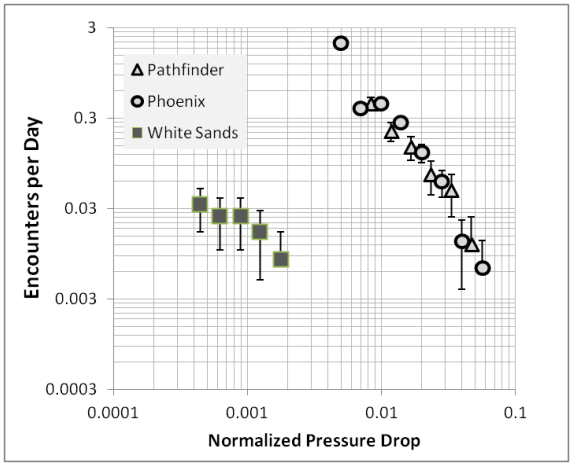

Figure 1. The differential frequency of normalized pressure drops (ΔP/P) attributed to nearby vortex passages as measured by Pathfinder and Phoenix and summarized in √2 bins [8] - note their similiarity. Previous terrestrial data (White Sands [8,9]) may suffer low detection efficiency and has poor statistics. The normalized pressure drop is a more rational basis for comparison between Earth and Mars than is the absolute value.

2. New Field Measurements

As noted in [8] new technologies (precision pressure sensors and in particular flash memory for data loggers) now permit sampling of pressure or other data with high precision (<0.1mbar), at the high rates (~1Hz) needed to resolve dust devil passage, for the periods (weeks) needed to obtain statistically-meaningful numbers of encounters. Furthermore, the equipment is now sufficiently small and affordable for instrumentation to be deployed and left unattended.

Using such a logger, I have obtained a 35-day record of 10Hz pressure data at 0.01mbar resolution between April and 21 May 2012 at a Nevada playa known for its dust devil activity [3]. Data downloaded the day prior to the EPSC abstract deadline shows - as expected - at least dozens of signatures (figure 2) characteristic of dust devil encounters. Additionally, contemporaneous timelapse imaging of the playa provides context - in particular the presence of large and long-lived dust devils.

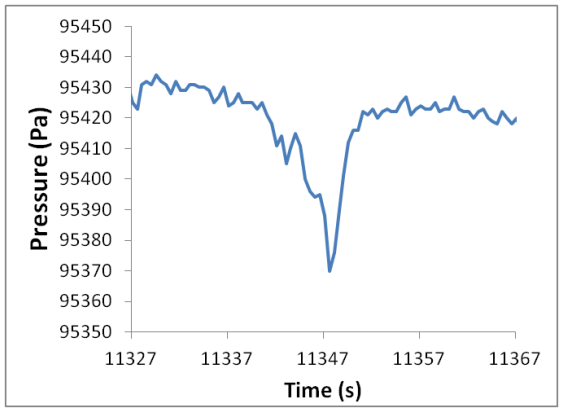

Figure 2. Transient pressure drop (~0.5mbar) recorded by new field instrumentation on 5th May 2012 due to probable dust devil. Analysis of these drops will provide improved statistics for Mars comparison.

3. Prospects

Many hundreds of MB of data have just been acquired, and a more elaborate analysis taking into account detection thresholds driven by the noise characteristics of the instrument will be presented.

The Nevada measurement campaign is ongoing through summer 2012, and thus it is expected that a much larger dataset can be reported at the meeting. Additionally, observations have begun at the Jornada Experimental Range in New Mexico to provide an indication of variability as a function of location.

Acknowledgements

This work was supported in part by the NASA Mars Fundamental Research Program .

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