A PRELIMINARY FIELD STUDY OF DUST DEVIL ACOUSTICS. R. M. Edmonds[1] and J. R. Murphy[1], [1]Department of Astronomy, New Mexico State University, Las Cruces, New Mexico, USA (redmonds@nmsu.edu).

Introduction: Vortices are known to produce sound. An easily observed (man-made) example is wake/wingtip vortices produced by airplanes. Several scientific investigations of wake/wingtip vortex sound have been conducted [e.g. 4]. Tornadoes may also produce sound. Infrasound observations have shown storms that produce tornadoes may produce infrasound as well [2].

Citing terrestrial infrasound observations of storms producing tornadoes, Williams [5] discussed the possibility of dust devils contributing to the acoustic environment of the Martian atmosphere. If the sound produced by dust devils is low enough in frequency (less than few to tens of Hz) it is possible the sound would not be substantially attenuated by the Martian atmosphere and could travel large distances (kilometers). This has been also suggested/repeated in other unpublished work and instrument proposals.

Several simplistic models exist to explain the generation of sound by vortices [3, 6]. Different models suggest different spectral characteristics and different amplitudes for vortex sound. When applied to dust devils in the Martian atmosphere, many of the models suggest sound should be generated at low frequencies (less than a few Hz) where absorption should be minimal in the Martian atmosphere. All of the models are dependent in some manner on the physical characteristics of the vortex, and thus tentatively hint that after further study perhaps there is an exciting possibility to remotely investigate the physical characteristics of dust devils.

InSight, a future Mars lander, may be able to take pressure measurements at a sampling rate in the few to tens of Hz range. The measurements, while not the focus of the mission, are intended to assist InSight in understanding how the atmosphere may contaminate a potential seismic signal. However, the measurements still provide an opportunity to better understand the Martian atmosphere. We are interested in the ability of InSight to detect dust devil sound, a phenomenon never previously recorded on Mars. However, we have also noted terrestrially there has been no published field study of dust devil acoustics. Which model best describes the sound generated by a dust devil, or even what the true spectral characteristics of a dust devil, are open questions. These issues need to be resolved to determine the feasibility of InSight to detect and discern dust devil sound from other sources.

We present observations from a field study of terrestrial dust devils. We have taken acoustic measurements in both the audible frequency range (generally considered >20 Hz), and inaudible infrasound frequency range (we define infrasound as < 20 Hz).

Vortex Models & Spectral Characteristics: Several basic models exist, and have been occasionally employed, to describe the potential generation of sound from dust devils. Co-orbiting point vortices or a rotating Kirchoff vortex patch model have been employed [2] to predict the frequencies of sounds produced by dust devils. These models would suggest a pure tone generated by a dust devil [3]. A vortex sound model for wingtip vortices also exists that generates a sound with broadband spectral characteristics [6]. The model implemented for wingtip vortices could be adapted for dust devils, and is a model not previously considered but suggests spectral characteristics different from pure tones. Given the likely spatially complex and time evolving distribution of vorticity within a dust devil, it is unlikely these models perfectly describe a dust devil. The actual sound generated by a dust devil may be better described by some combination of the models, or is more complex than what can be captured by these simple 'toy' models.

Observations:

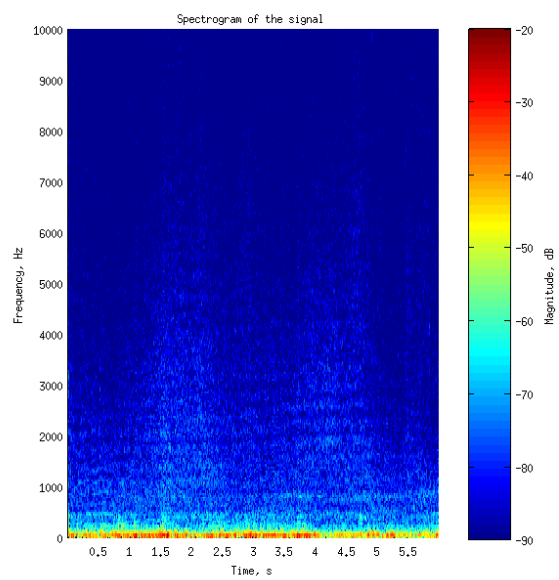

Figure 1: A spectrogram of a potential acoustic signal from a terrestrial dust devil. Note; the reference pressure is undefined.

Our preliminary field study has focused on a geographic region near Deming, NM. The site has provided several opportunities to take sound recordings at a

range of meters to hundreds of meters from dust devils. To make the observations we have used a commercially available microphone and microbarometer.

Wind noise and other noise considerations have produced significant challenges in identifying sound generated by a dust devil, and is carefully considered in our field study. Nevertheless, a recording of sound from a dust devil has been potentially identified and is presented in Figure 1. While confident the sound is not produced by wind noise, with some analysis to support this claim, further work addressing how much surface vegetation (not a Mars concern) potentially altered the signal still needs to occur. To date, so far no pure tone dust devil signals have been identified. This would perhaps suggest that dust devils may be better described by some source that generates a broadband spectrum of sound. There are specific observational challenges to discerning this type of signal from other noise sources, and we discuss the observational methodologies and analysis techniques implemented, or to be later implemented, to overcome this obstacle in detecting dust devil sound.

References:

[1] Banfield, D. (2014), Atmospheric Observations from the Mars Insight Mission, The Fifth International Workshop on the Mars Atmosphere: Modelling and Observation, [2] Bedard Jr, A.J. (2005), Low-Frequency Atmospheric Acoustic Energy Associated with Vortices Produced by Thunderstorms, *Monthly Weather Review*, 133, 241-263. [3] Howe, M. S. (2003), Theory of Vortex Sound, Cambridge University Press, Cambridge, UK. [4] Rubin, W.L. (2005), The Generation and Detection of Sound Emitted by Aircraft Wake Vortices in Ground Effect, *Journal of Atmospheric and Oceanic Technology*, 22, 543-554. [5] Williams, J.-P. (2001), Acoustic environment of the Martian surface, *JGR*, 106, E3, 5033-5041. [6] Zhang, Y., Wang, F.Y. and Hardin, J.C. (2003), Spectral Characteristics of Wake Vortex Sound, NASA Technical Report, During Roll-Up, NASA/CR-2003-212673.