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Dust Devils: Whirlwinds on Earth and Mars

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Special points of interest:

- Dust Devils
- Astronomy clubs
- Triton Fun stuff
- Superfluous questions

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Dust devils are fascinating atmospheric phenomena. I remember the first dust devil I ever saw. I was at a rest stop in Amargosa Junction on the California/Nevada border. It was an unusually warm day in mid-March, and I was so surprised to see anything interesting meteorological that I didn't have a camera at hand to capture the moment. But I remember watching some vacationing family being overcome by a **small whirl of dust** and doing alot of coughing thereafter. Growing up in the East and being educated in the Midwest made the experience quite novel. Thus I was somewhat surprised the following April to see a dust devil (~20 m. in diameter) moving over a cornfield just north of Urbana, Illinois. What was the common denominator of these events? Unusually hot and dry weather on both counts.

Residents of the hot deserts of the world, however, might not share my awe. The **dust devil**, or the "willy-willy", as the Australians call it, is a common sight in the summer months in those climes. The denizens of the deserts, however, might be surprised to learn that dust devils also are observed in the Arctic. Stranger still, the same basic weather phenomenon that produces dust devils is also responsible for some of the leaf and plastic-bag-stirring swirls I remember from my city childhood and the clear day summer waterspouts that tease and tip Florida's fishermen.

Indeed, all of these **whirls** might be called **cousins to the tornado**, differing from their typically more violent relation only in the source of their energy. Tornadoes feed on the latent heat from the condensation of water vapor, whereas dust devils and their ilk form from the instability between a surface strongly heated by the Sun and much less intensely heated air above. The air near the surface expands and becomes thus less dense than the air above it, and if the difference in density is sufficient, the air near the surface **overturns** so that the lighter air lies over the heavier air. If this convective overturning is sufficiently vigorous, the near-surface air begins to **rotate** parallel to the surface, acting as a miniature low pressure system that draws in very warm near-surface air. This air likely provides both energy and angular momentum to the miniature low-pressure center, and the **whirl rotates faster and faster**. If the whirl rotates fast enough, dust can be lifted by simple wind action or by more exotic means.

Typical dust devils on the Earth have winds of 10 ms^{-1} (20 mph), last a few seconds, and have diameters about the size of the average saguaro cactus (5 m., 16 ft.). But a great range is possible in all of these characteristics. In Arizona and New Mexico, a few dust devils have been confused with tornadoes, since **their winds were strong enough to destroy barns and outhouses**. Dust devils have been observed to last up to seven hours and travel 100 km (60 miles) or more. These long-lived dust devils can have diameters of more than 100 m (300 ft.). But wait a minute! I said that these were the characteristics of dust devils on Earth. Where else are dust devils found ? On Mars.

The existence of dust devils on Mars had been hypothesized as early as 1964 in order to explain how dust might be lifted on Mars to produce the persistent hazes seen on the planet. But it was not until the Viking missions that combined observations from both landers and orbiters that confirmed the idea. On the ground, the Viking weather stations observed sudden short-lived drops in atmospheric pressure. At the same time, the same stations measured strong winds that rapidly changed in direction. Photographs taken by the orbiter showed dust plumes that cast shadows large enough to be visible. Although simultaneous observation of a dust devil at the surface and from orbit never took place, correlations between times of high plume activity and weather station observations

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Dust Devils, continued

suggested that the dust plumes were produced by convective vortices. In other words, they were dust devils.

Since Viking, dust devils have been observed by the **Pathfinder** lander (photographically and from weather station data), by the Mars Orbital Camera on **Mars Global Surveyor**, and by the THEMIS instrument on **Mars Odyssey**. Most recently, both of the **Mars Exploration Rovers** have observed dust devils, especially Spirit, which took enough images of one dust devil in Gusev Crater to make a video.

(See the following website: http://marsrovers.jpl.nasa.gov/gallery/press/spirit/20050527a.html for a wonderful movie of an active dust devil whirling across the landscape in front of the Spirit lander.) Dust devils also may have added to the long lifetimes of these spacecraft. Both rovers have experienced "dust clearing events," in which dust was swiftly removed from their solar panels and other instruments. Images from the period of the dust clearing events contain some dust devils, suggesting that they are the most likely cleaning agents.

Dust devils can lift particles over a range of sizes. (Fisher et al, 2005) It is thought that the lifting comes primarily from the **suction effect of the low-pressure center** of the vortex, rather than simply the high-velocity winds swirling around it (sort-of like the effect of the cyclone that carried Dorothy's house aloft in "The Wizard of Oz").

Martian Whirlwinds

A dust devil traveling across the Martian landscape captured in this image by the Mars Exploration Rover Spirit lander on May 15, 2005 *Photos:NASA/JPL*

Despite two decades (on and off) of observations, the full range of characteristics of Martian dust devils still remains a mystery. It is thought they are generally bigger and have more intense winds than those on Earth. How much bigger? Well, the first detection of a dust devil from Martian orbit was reported in 1985 by re-examining Viking photographs taken several years earlier. The first orbital detection of a dust devil on Earth occurred during the summer of 2004. It is fairly easy to see something 500 m. (1600 ft.) in diameter and up to 7000 m. (23000 ft.) high! Martian dust devil winds are estimated to peak at 100 ms^{-1} (220 mph), but with the lower atmospheric density, the windiness from these dust devils on Mars would only feel like that of a small storm.

Several unanswered questions remain about dust devils, the chief of which is: how exactly do they form? It remains quite a leap from the near-surface air convecting to creating intense rotation. One fascinating idea is that rotation of the medium can suppress convection, and thus convection must be exceptionally intense in order to maintain a dust devil. If this idea is correct, tiny bits of rotating air likely move their way across the surface of the Earth and Mars all the time but can only become dust devils, paper bag whirls, or waterspouts when the contrast between the surface temperature and the near-surface air temperature is especially strong.

If manned missions to Mars take place, dust devils may become more than a desert curiosity. At the least, future Martian drivers might appreciate a little notice before they enter the low visibility of an active dust devil zone. Understanding how dust devils form, what controls their winds, size, and lifetime, and how they lift dust are important steps toward weather forecasting for the exploration of another world.

References: Balme, M. and R. Greeley, Dust devils on Earth and Mars, *Reviews of Geophysics*, 44, RG3003 (2006)

Fisher, J et al. , A survey of Martian dust devil activity using Mars Global Surveyor MOC camera images, *J. Geophys. Res*, 110, E03004 (2005)

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Superfluous Questions:

1. What chemical element has the highest density ?

   a) Lead b) Thallium c) Tantalum d) Osmium

2. How many chambers are there in a bird's heart ?

   a) 2 b) 3 c) 4 d) 5

3. In the TV show "Space:1999", how many crew members were working on Moonbase Alpha when the Moon left Earth orbit ?

   a) 215 b) 311 c) 454 d) 847

4. Where is Timbuktu ?

   a) in the country of Mali b) in the country of Gabon c) in the country of Morocco d) in the country of Mauritania

—-> ANSWERS in next months issue of the Science Newsletter ! <——-

** ANSWERS to October's Superfluous Questions: 1. c) Ian Shelton 2. d) Pittburgh 3. d) Menara 4. d) Valley Quail