A 20-STATION ARRAY OF INTELLIGENT DATALOGGERS TO STUDY TERRESTRIAL DUST DEVILS : PRELIMINARY TRIALS. Ralph D. Lorenz JHU Applied Physics Lab, 11100 Johns Hopkins Road, Laurel, MD 20723, USA. email: ralph.lorenz@jhuapl.edu

Introduction: The 2-D horizontal structure of dust devils is not well-understood, since data in most studies so far is acquired from a single (fixed or moving) station. Sampling bias from truck-mounted surveys which of necessity chase the largest, dustiest devils calls into question some of the statistics of physical properties such as pressure and dust loading. Here I report initial efforts to study dust devils with an array of many small, intelligent dataloggers, generating an entirely new class of dataset for the study of this phenomenon.

Trial: A field trial with an initial array of 20 dataloggers (based on the PICAXE-18X microcontroller, programmed by the author in BASIC) was conducted in September 2007, northwest of Tucson, AZ. Each logger (with a parts cost of <$100 including sensors) measures pressure, light level, temperature and a passive microphone (used as a proxy for turbulent wind intensity) once a second for an hour.

The logger program can be revised in the field if necessary : presently it performs selective logging and digital signal processing (storing time-tags once every 100 records, rescaling the temperature and light level sensors to maximize the utility of each 1-byte measurement; averaging of several 10-bit pressure reading and rescaling into 1 byte, and recording the total of the differences between successive microphone samples, rather than the absolute value.)

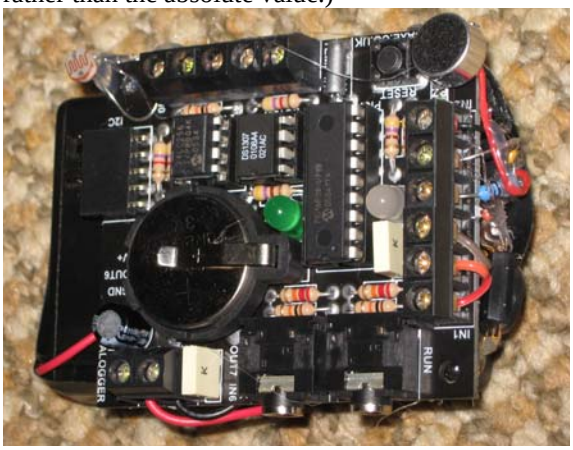

Figure 1. A photo of one of the loggers, little bigger than the 3 AA cell power supply underneath.

The array was deployed in an E-W line (although 2-D deployments can of course be envisioned in future) with stations separated by ~3m. The array was broadsided by a large dust devil after ~30mins. After the 1-hr acquisition period the array was recovered and data downloaded to a laptop via serial cable (two loggers failed to return good data.)

Figure 2. Image of the dust devil documented in this report.

Results: The sensor suite (Freescale pressure, DS1820 temperature, CdS LDR light sensor and electret microphone) is chosen for low power and low cost. Nonetheless, all of the elements appear to give useful signatures of the dust devil and the software-controlled datalogging was successful (although only partially so in the case of the pressure record.)

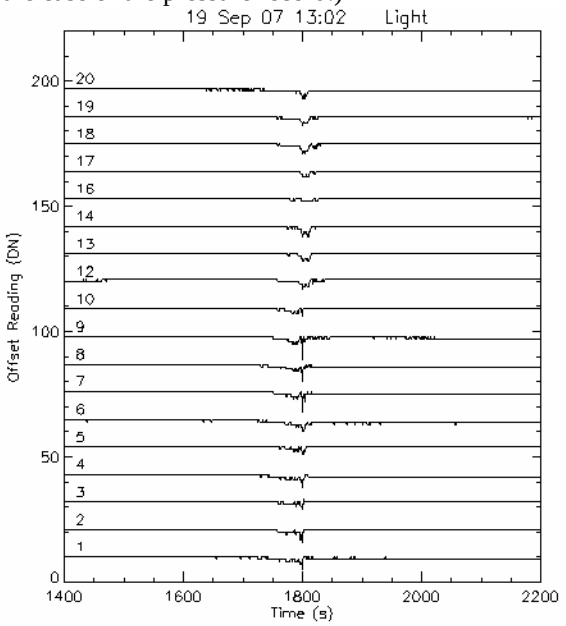

Figure 2. The passage of a dust devil is recorded in the light level record of all of the 18 operating dataloggers (data from loggers 11 and 15 was lost).

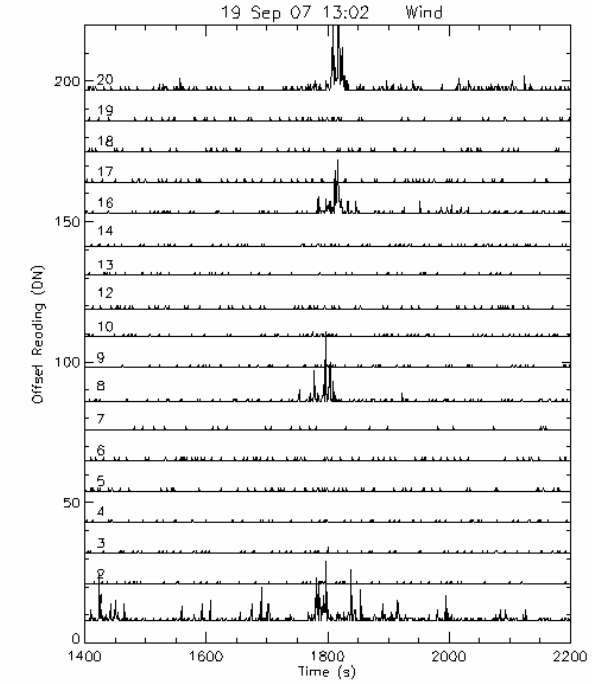

Figure 4. Passive microphone indicates wind: it is not yet understood why this signal appears only on 4 widely-separated loggers and not on the others.Record shown is the sum of differences between 20 readings and thus indicates fluctuations in dynamic pressure.

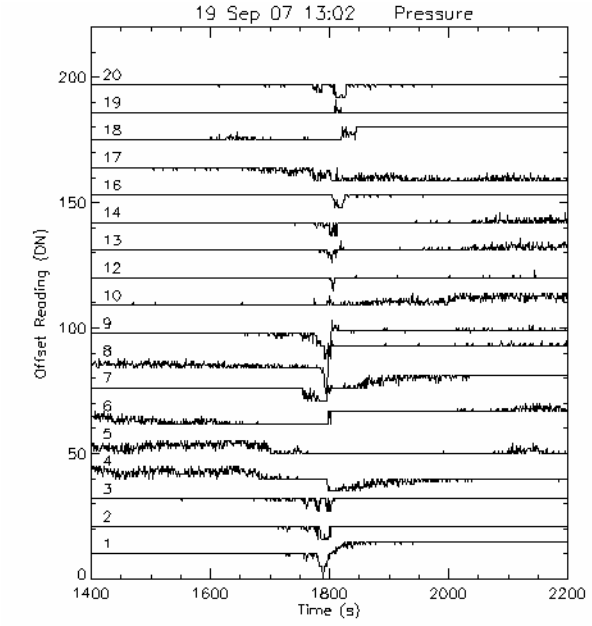

Figure 5. A pressure perturbation can be discerned on 12 of the 18 loggers : unfortunately a coding error resulted in clipping of data so some loggers missed the pressure event due to a slowly-changing baseline.

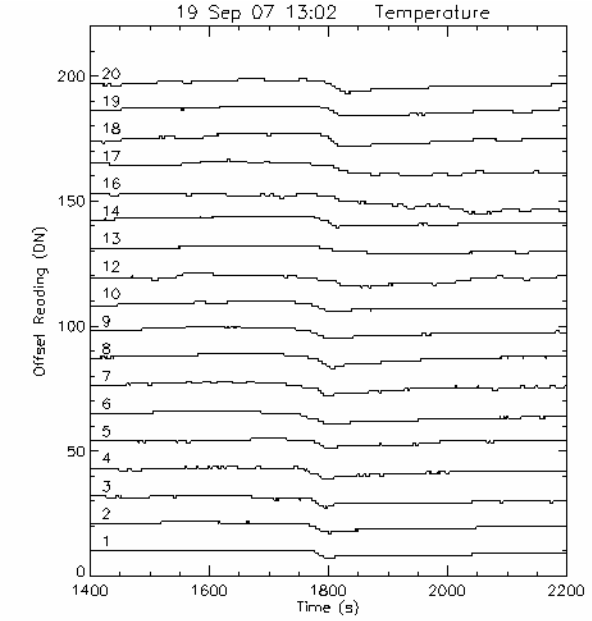

Figure 6. The temperature of all loggers dropped and in most cases did not recover fully – presumably due to deposition of bright dust changing the radiative balance of the loggers.

The large size of the devil was paradoxically inconvenient, in that the whole array was stimulated, rather than allowing the array to define a 'size' of the devil. Inspection of the data shows clear signatures and suggests that simple rule-based event detection can be implemented on the PICAXE microcontroller. This opens the way for much longer surveys, and possibly intelligent arrays wherein one sensor triggers the others.

Conclusions: These initial results show considerable promise : it is believed that these simultaneous records of many locations across a single dust devil are unprecedented. Field trials in summer 2008 with a more capable array are planned. The microcontroller approach has proven to be versatile, capable of generating useful statistics of sensor readings rather than merely recording the raw values.

The trials identified several areas for enhancement. These include automating or at least streamlining the data download process, perhaps wirelessly. Synchronization of the array records requires some effort, and GPS receivers are now becoming sufficiently affordable to make that a viable option. Increasing memory storage and/or implementing on-board event detection will allow much longer observation periods, even at higher sample rates.

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