A PORTABLE INSTRUMENT FOR ATMOSPHERIC MEASUREMENTS. Fernando A. Saca, Nilton O. Renno, Douglas G. Halleaux, Steven Rogacki, Robert Gillespie and Stephen Musko (renno@alum.mit.edu) Department of Atmospheric, Oceanic and Space Sciences, University of Michigan, Ann Arbor, MI 48109, USA

Introduction: Renno [1] proposed a theory for convective vortices that generalizes Bernouilli's equation to convective circulations. This theory indicates that a minimum in the static pressure forms in regions of maximum windspeed, such as around the core of convective vortices. In order to test this theory, simultaneous measurements of wind, static and dynamic pressures are necessary. A Prandtl tube allows both pressure measurements to be made at a single point, permiting comparisons between the two pressures and the windspeed.

The instrument: We developed an instrument to test the theory described above. The instrument consists of a a freely rotating cylinder subassembly containing a Prandtl tube, pressure sensors, batteries, and supporting electronics. In addition, the instrument includes a data processing unit (DPU) that receives the data from the pressure sensors and the Prandtl tube azimuth wirelessly, a sonic anemometer, and electric field sensors. The Prandtl tube spins freely and is forced to point towards the wind by aerodynamic forces acting on its fin. The sonic anemometer measures the 3-d wind vector at 10 Hz, and up to four cylindrical field mills measure the 2-d electric fields on planes perpendicular to their axis of rotation. The electric field sensors can be used to detect clouds of dust by measuring their electric signature. The complete system with a single field mill is shown in Fig. 1.

Fig. 1. Our instrument includes a Prandtl tube mounted on 10 m tall mast, a sonic anemometer (right) and electric field sensor (left). The DPU and supporting electronics are in a box at the base of the mast.

The static and stagnation pressures are measured at 10 Hz with Setra pressure transducers. The pressure values and the azimuth of the Prandtl tube are measured at 10 Hz and converted from analog to digital before being transmitted to the data processing unit (DPU) by the wireless link. The DPU contain a GPS receiver that is used to time stamp the processed data and record the data on a flash card as CSV files. A 4-cell battery allows 14 hours of continuous operation of the Prandtl tube subassembly. The batteries can be recharged using an external DC charger.

From May to June of 2009, this new instrument was used to make measurements in dust devils in Eloy, AZ and the Eldorado Valley, NV. The instrument was placed on a 10 m mast while dust devils passes were recorded by an operator. The data collected at the field showed a clear anti-correlation between static and staganation pressures around the center of dust devils (Fig. 2). The passage of dust devils over the instrument were indicated by a 360^o rotation in the wind direction.

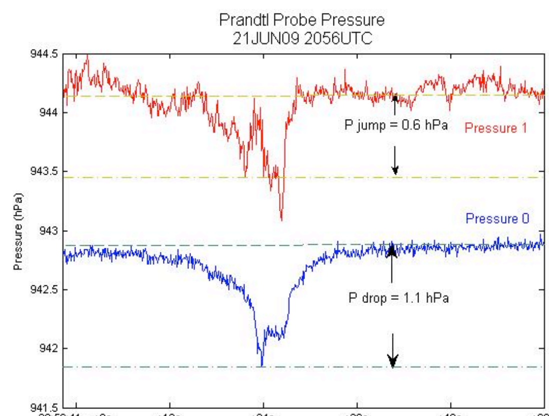

Fig. 2. Stagnation (red) and static (blue) pressures during the passage of a a dust devil. The fall in static and rise in stagnation pressure at 24 s (the region of maximum wind) proves Renno's theory [1].

Conclusions: We developed a portable instrument to measure the static and stagnation pressures in atmospheric systems, simultaneously with measurements of the 3-d wind, and the 3-d electric field vectors up to 10 m above the ground. This instrument proved Renno's general theory for convective vortices [1].

References:

[1] Nilton O. Renno (2008) *Tellus, 60A, 688–699.*