Wind fields and aerosol structures from the REAL at M²HATS

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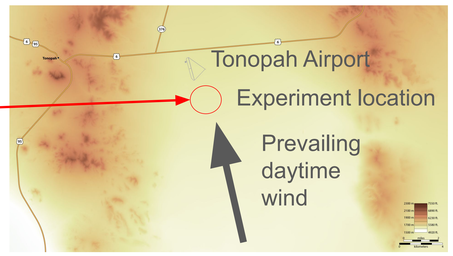
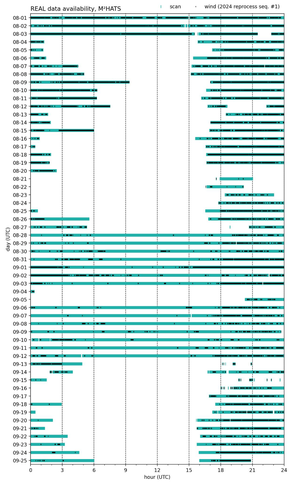
Objective: To observe turbulent horizontal vector wind fields in the surface layer in order to validate **multipoint Monin-Obukhov Similarity Theory (MMO)**. See the following papers for a description of MMO:

Tong, C., and K. X. Nguyen, 2015: Multipoint Monin–Obukhov Similarity and Its Application to Turbulence Spectra in the Convective Atmospher Surface Layer. *Journal of the Atmospheric Sciences*, 72, 4337–4348, https://doi.org/10.1175/JAS-D-15-0134.1.

Tong C., and M. Ding, 2019: Multi-point Monin–Obukhov similarity in the convective atmospheric surface layer using matched asymptotic expansions. *Journal of Fluid Mechanics*, 864:640–669. https://doi.org/10.1017/jfm.2019.38

Experiment: **Multipoint MOST Horizontal Array Turbulence Study (M²HATS)**. We deployed the REAL and other observing systems in a flat, dry, high desert (1655 m ASL) environment near Tonopah, Nevada, from 23 July to 25 September of 2023. We collected over 55,000 horizontal scans at 5 m AGL.



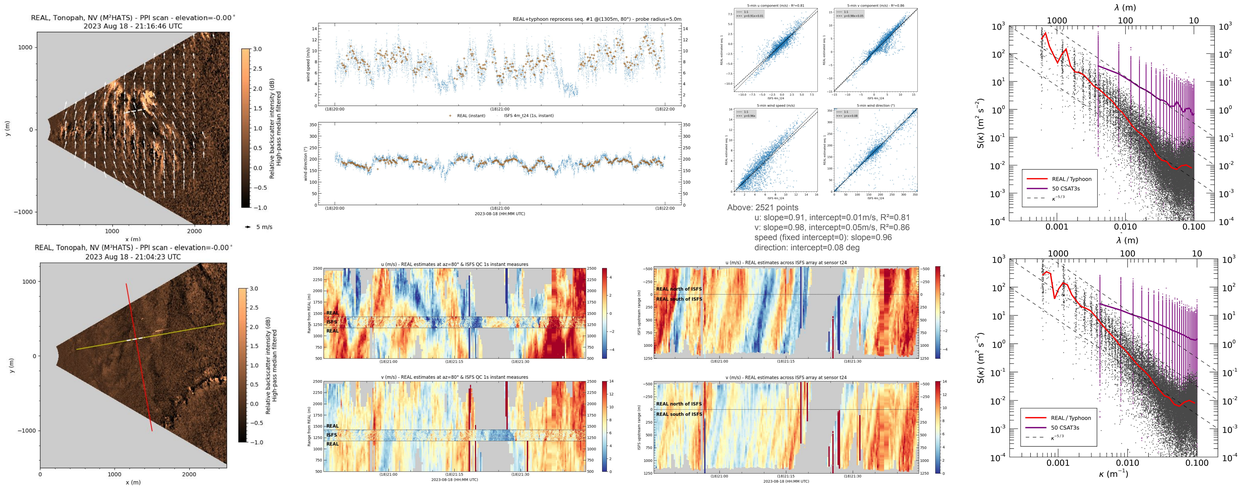


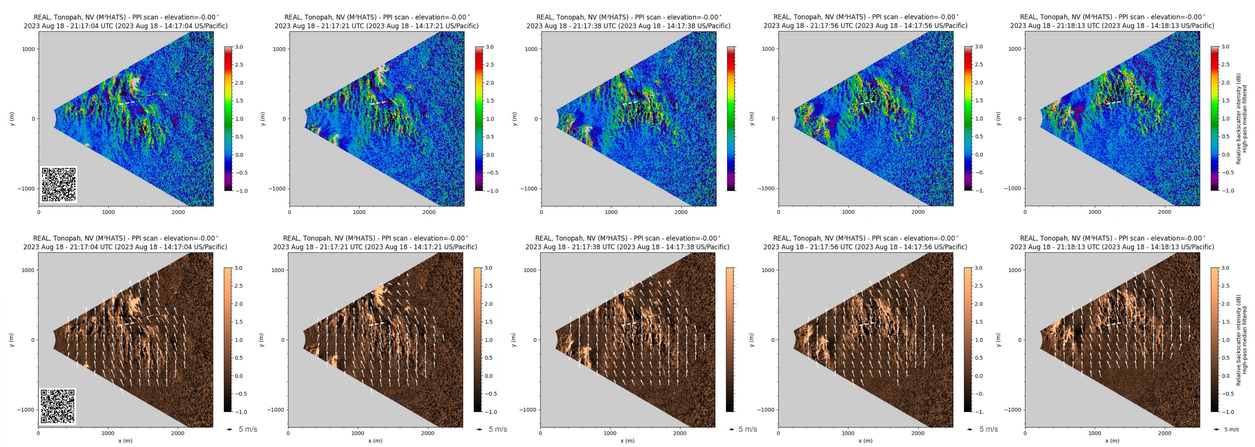
The **Raman-shifted Eye-safe Aerosol Lidar (REAL)** scanned horizontally at 5 m AGL and above a linear array of **50 sonic anemometers** spaced 5 meters apart at 4 m AGL. The REAL is a scanning elastic backscatter lidar at 1.54 microns wavelength. It transmits 130 mJ/pulse at 10 Hz, uses a 40 cm diameter telescope, InGaAs APDs, and a 14-bit 100 MSPS ADC. For more information on the REAL, please see:

Mayor, S. D., S. M. Spuler, B. M. Morley, and E. Loew, 2007: Polarization lidar at 1.54-microns and observations of plumes from aerosol generators. *Optical Engineering*, **46**, 096201. https://doi.org/10.1117/1.2786406

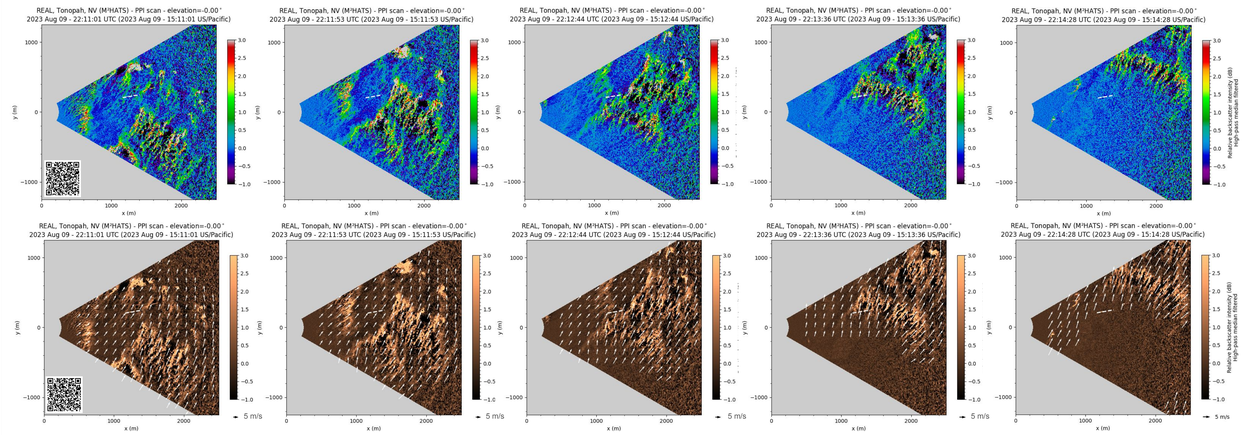
Typhoon: The rich aerosol imagery make it possible to derive **2D vector flow fields** by applying the Typhoon wavelet-based **optical flow** algorithm. Vector fields with horizontal spacing of 8 m in both dimensions are provided every 17 s. For more on the Typhoon algorithm, please see:

Dérian, P., C. F. Mauzey, and S. D. Mayor, 2015: Wavelet-Based Optical Flow for Two-Component Wind Field Estimation from Single Aerosol Lidar Data. *Journal of Atmospheric and Oceanic Technology*, 32, 1759–1778, https://doi.org/10.1175/JTECH-D-15-0010.1.

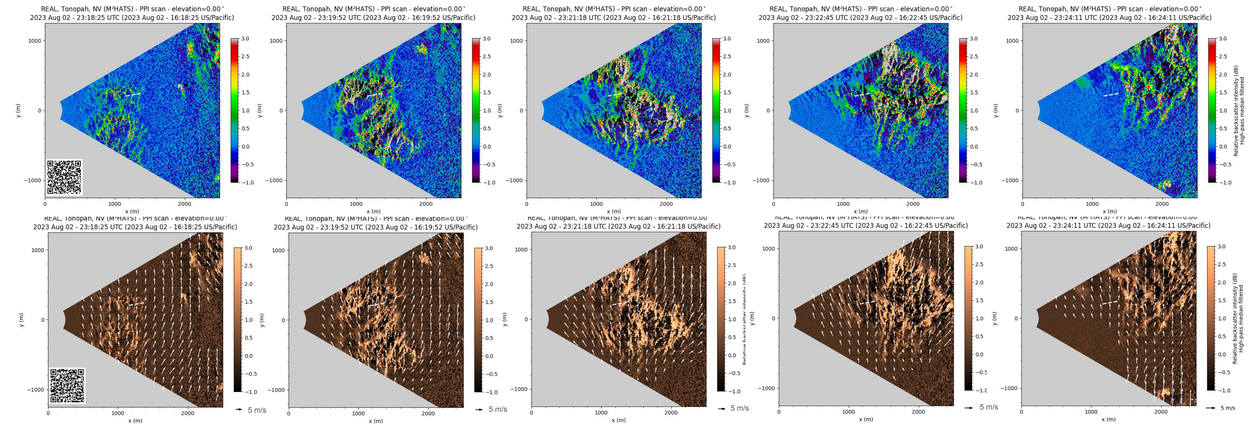




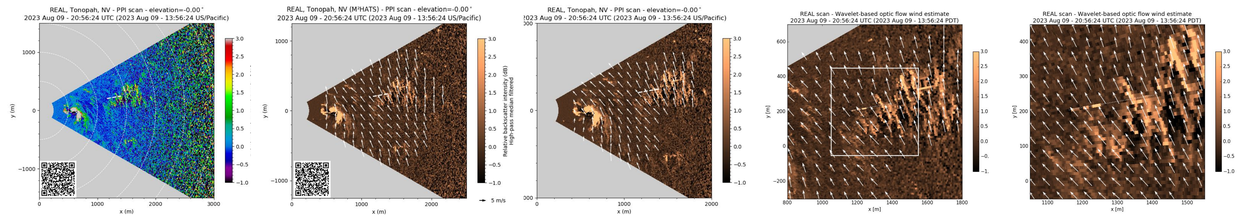
The most interesting discovery thus far is the frequent occurrence of large **crescent-shaped aerosol structures** during windy and convective afternoons. They advect with the mean flow and resemble cat's paws.



Embedded within the crescent-shaped structures are many fine-scale wind-parallel streaks. The flow fields suggest they are followed by a broad area of **horizontal divergence**.



The images below show the ability of the REAL & Typhoon to provide **high-resolution images and flow fields**.



Future work: We plan to compute 2D and ring integrated velocity spectra, and develop a comprehensive description of the crescent-shaped structures using data from multiple observing systems.

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Lidar group

M²HATS