Application of Triple Doppler Wind Lidars for the Study of Atmospheric Boundary Layer over a Mountainous Area

Yansen Wang[1], Edward Creegan[1], Melvin Felton[1], Giap Huynh[1]
Christopher Hocut[1,2], H. J. S. Fernando[2],
Sebastian Hoch[3], David Whiteman[3]

[1] U.S. Army Research Laboratory
[2] University of Notre Dame
[3] University of Utah

Presentation to AGU 2013 Fall Meeting (12/9/2013)

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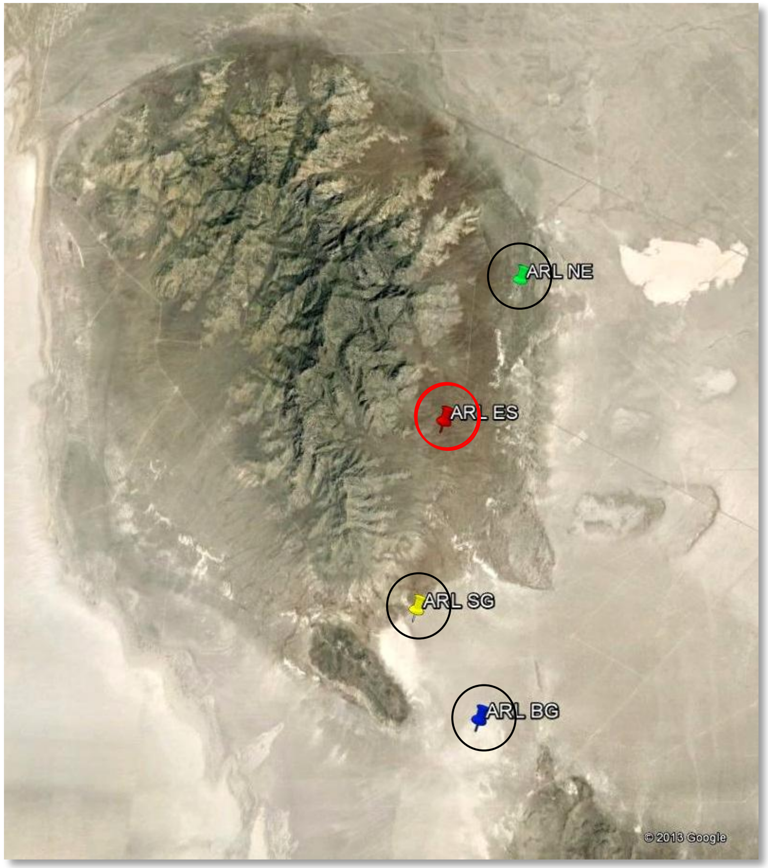
ARL Participation of MATERHORN

- Participated in both MATERHORN-X field campaigns

- MATERHORN-X-1 (Fall 2012):
  IOPs 1 - 3 at Small Gap
  IOPs 4 - 6 at East Slope
  IOPs 7 - 9 at Big Gap

- MATERHORN-X-2 (Spring 2013):
  IOPs 4 - 6 at East Slope
  IOPs 7 - 10 at NE of Granite Mountain



* Red color IOPs: triple lidar coordinated scans with UND and UU

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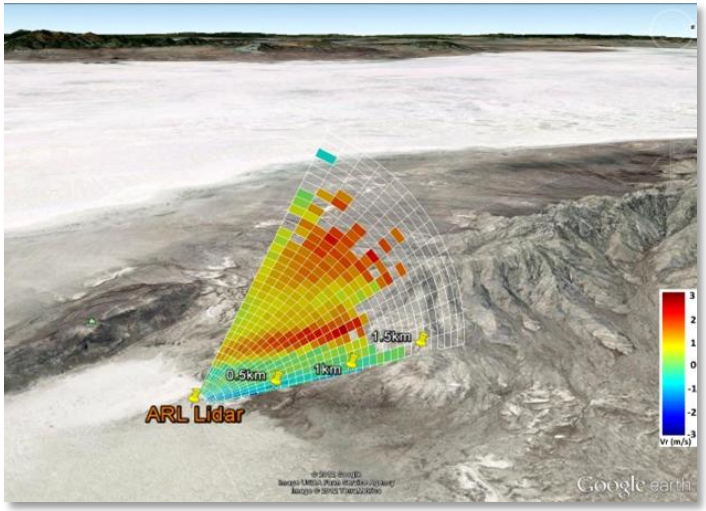
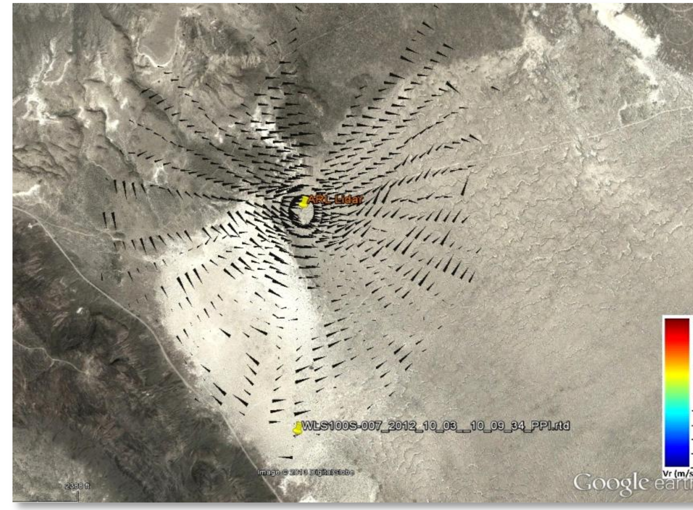
MATERHORN-X-1 Locations and Scanning Patterns

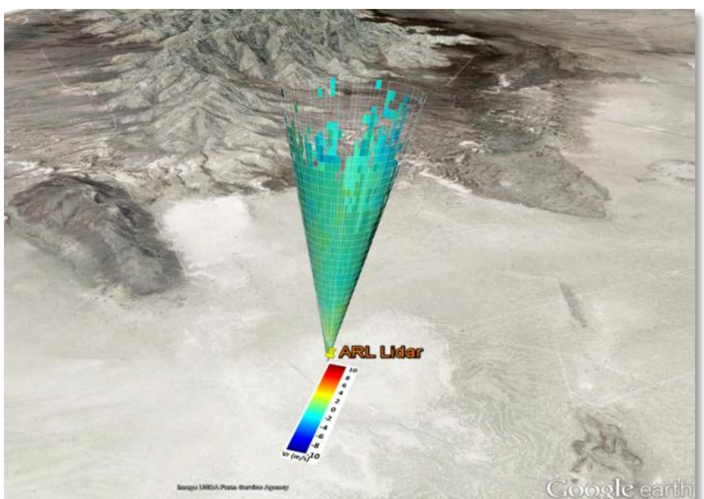
ARL



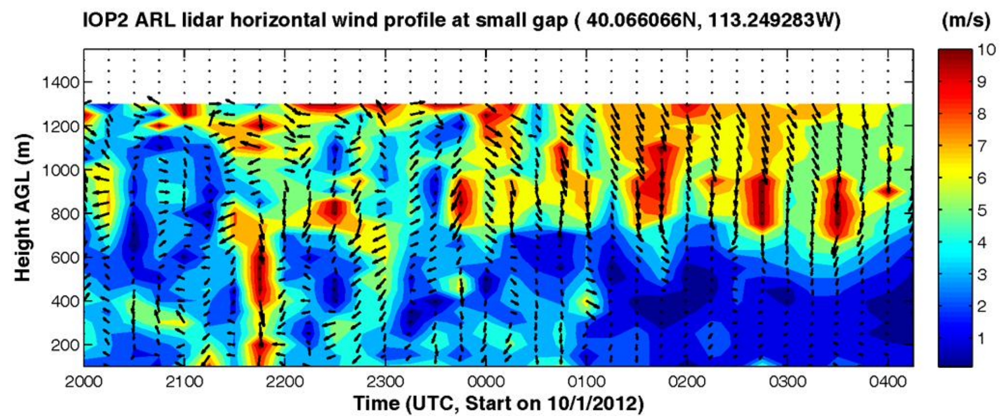
RHI at Small Gap



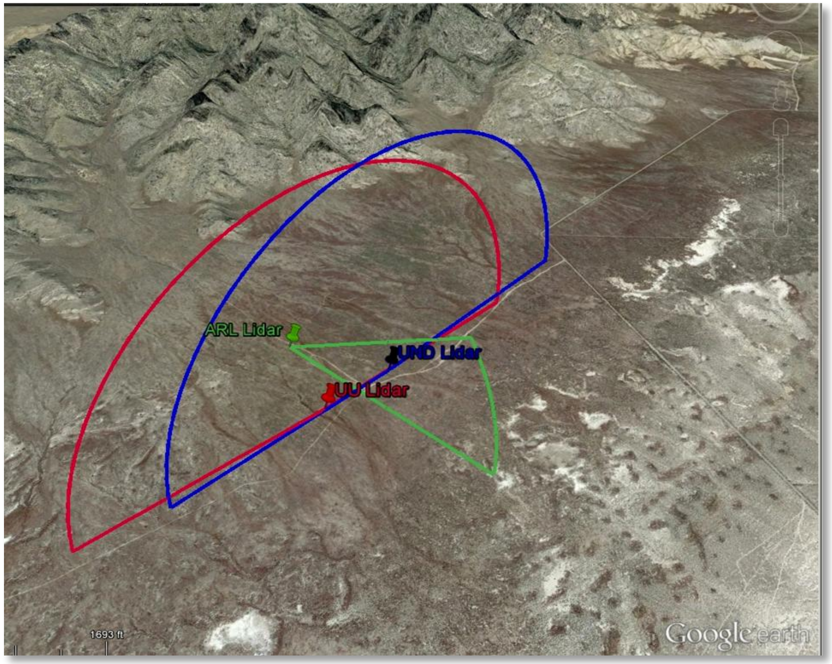
Near Ground PPI at Small Gap



VAD (PPI) at Big Gap



Triple Lidar Scans at East Slope MATERHORN-X-1



Lidars:

ARL: Leosphere Windcube 100s

UND/UU: Halo Photonics Stream Line

Setup:

- **ARL lidar scanned RHI downslope towards ES2 tower**
- **UND and UU lidars scanned coplanar 180° RHI**
- **Data used for virtual tower if all three lidar beams crossed within 10 s (Calhoun et al. 2006)**

Challenges:

- **Due to programming limitations, UND and UU lidars were only able to continuously scan one RHI**
- **UND and UU lidars scanned outside of the possible beam intersection area, limiting the potential beam crossings**
- **Lidar synchronization issues**

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Triple Lidar Scans at East Slope MATERHORN-X-2

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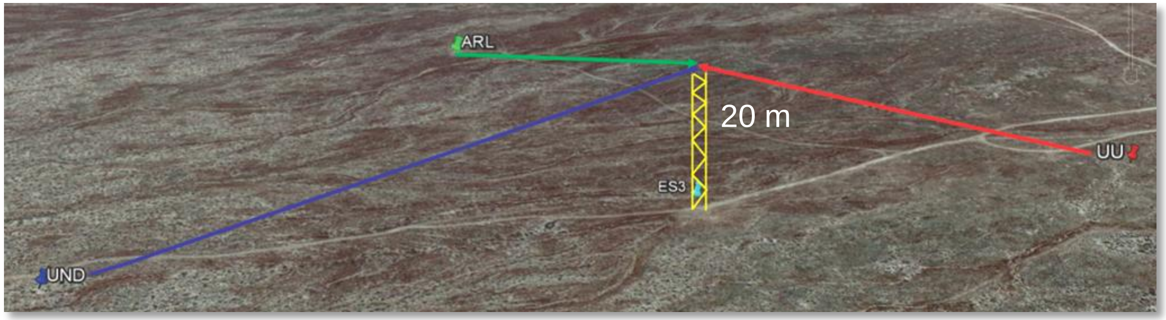
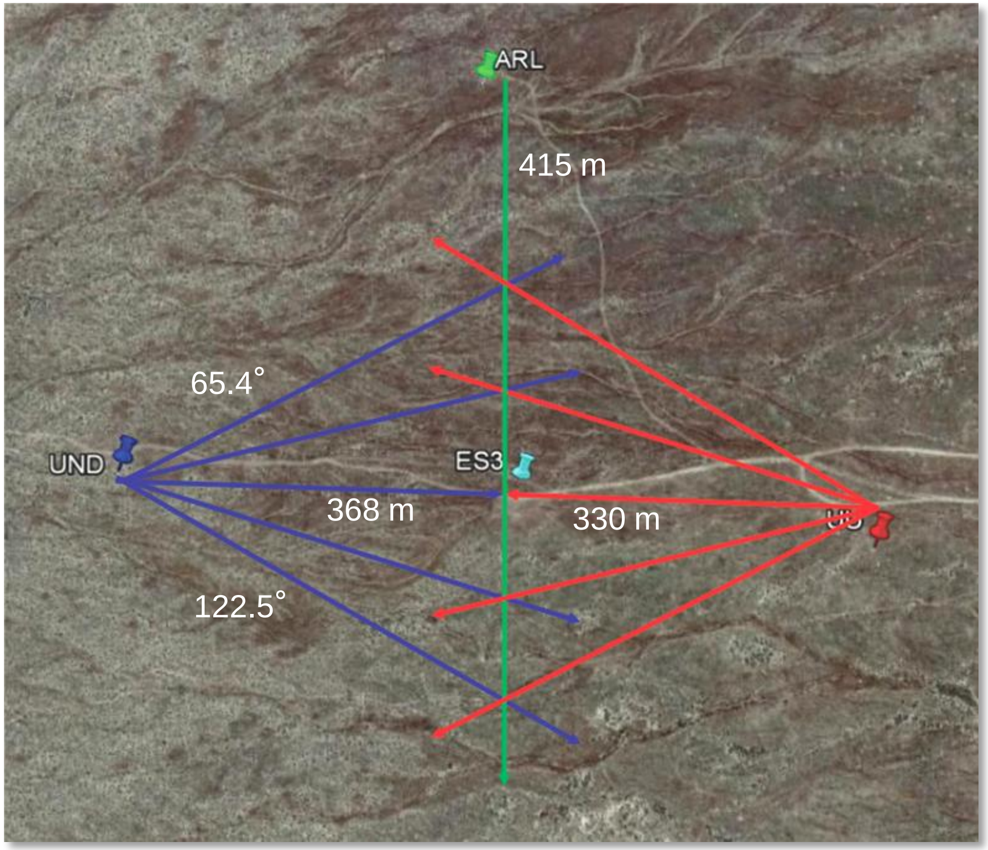


Phase 1: Stare Scans

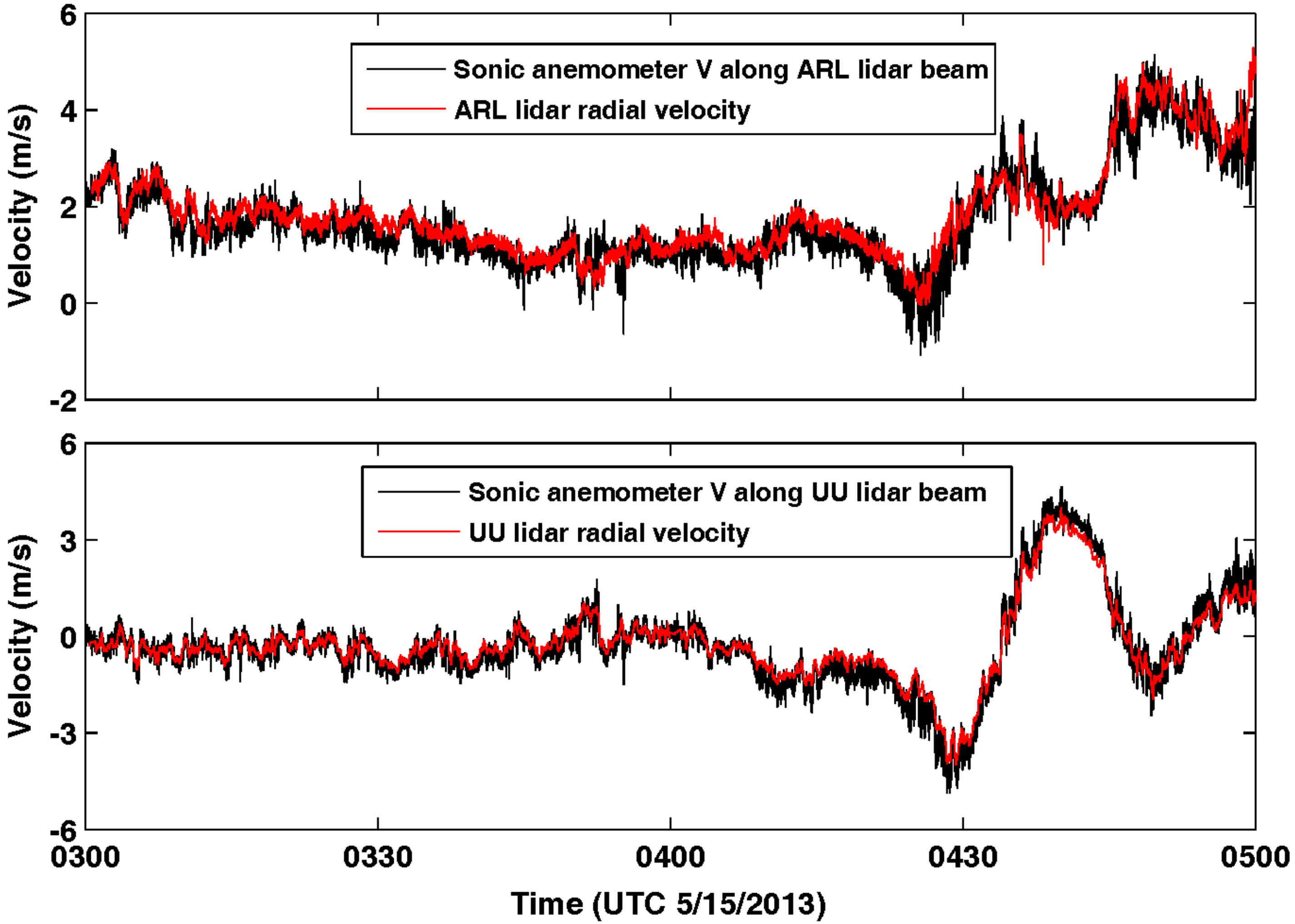
- All three lidars starred at the ES3 20 m Sonic
- Comparison with sonic used for 3-D vector retrieval verification



Phase 2: 3-D Tower Mode

- Halo programming improved allowing Halos to scan multiple RHIs, intersecting the ARL lidar RHI
- Improved synchronization - after a series of 160, 45° RHI scans, Halos were within 10 s of each other
- Created (5) 3-D VT more than 300 m in height spaced 100 m apart

Comparison of Lidar Stare Scan Data with Sonic



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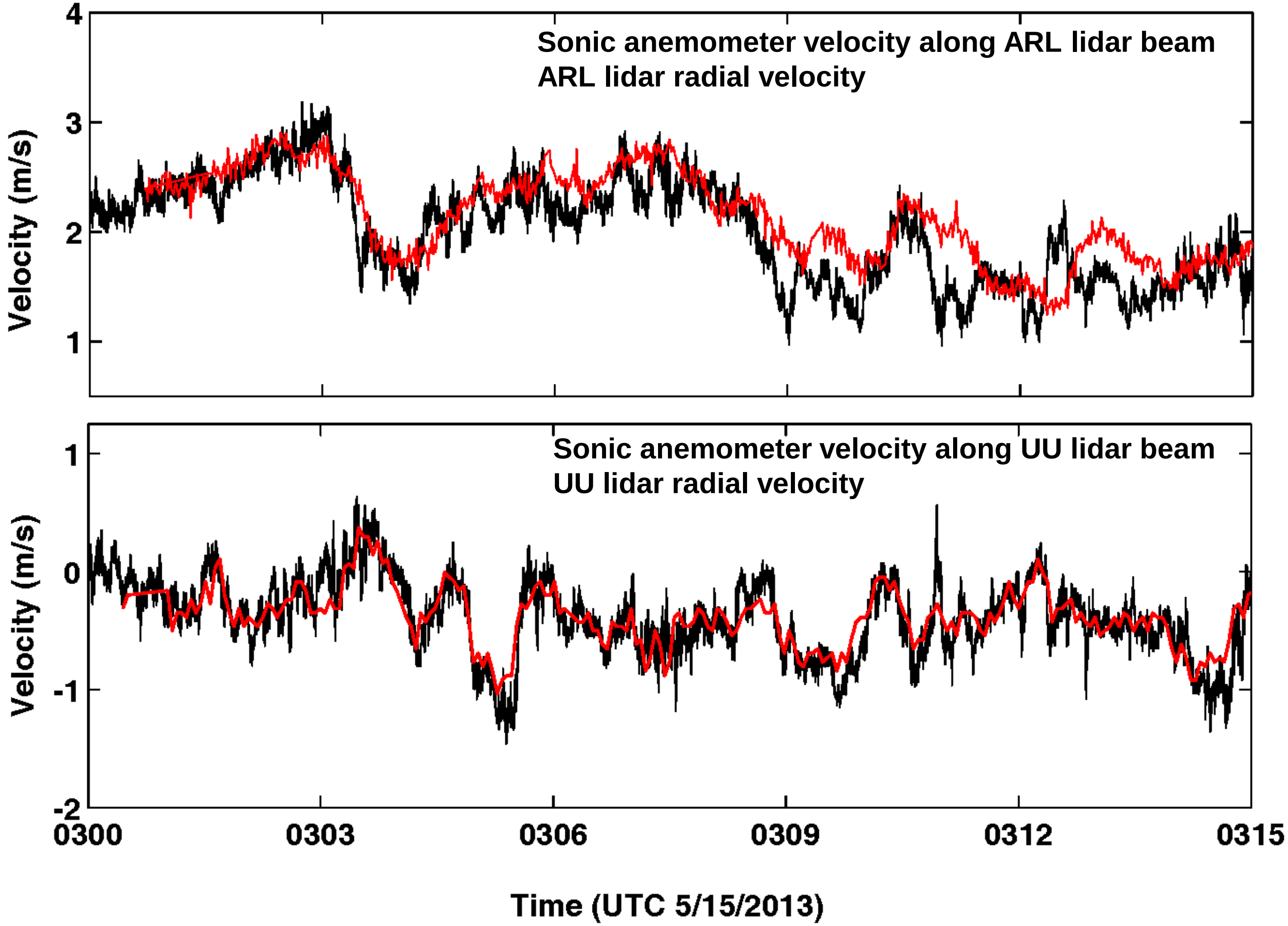
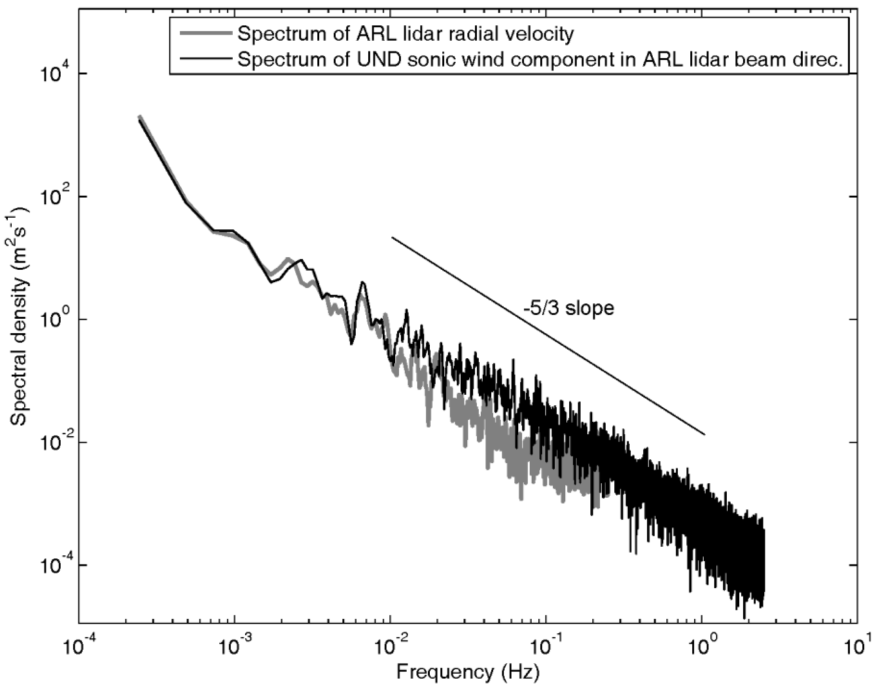
Comparison of Lidar Stare Scan Data with Sonic (zoomed)

ARL

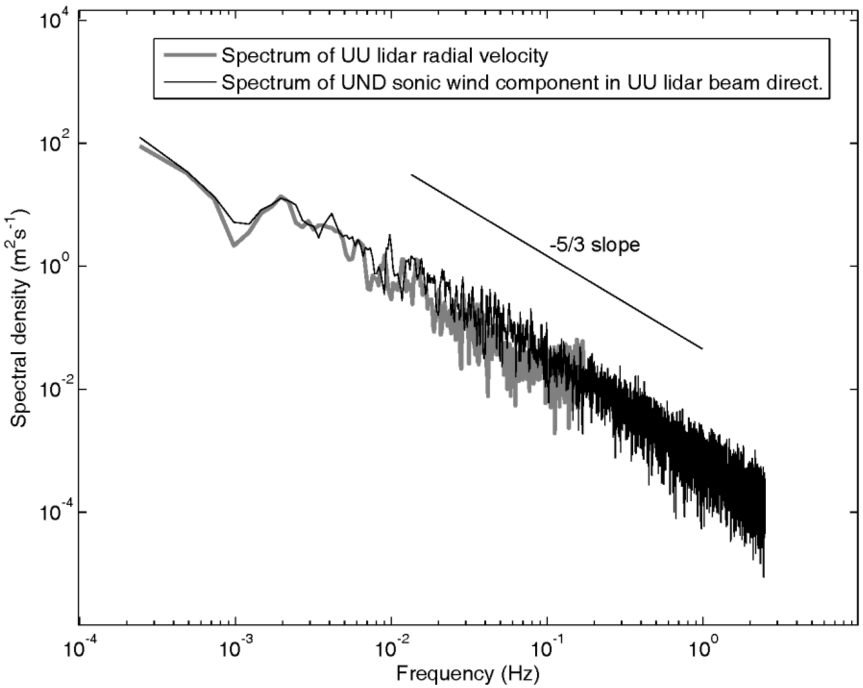


Comparison of the Sonic and Lidar Radial Winds in Spectral Domain

ARL lidar Compared with Sonic Anemometer



UU lidar Compared with Sonic Anemometer



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Examples of Triple Lidar Retrieved Virtual Towers (10/7/2012)

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Time (UTC)	Lat.	Lon.	Z (m AGL)	U (m/s)	V (m/s)	W (m/s)
11.15837	40.09638	-113.23779	57.65129	-0.22	1.21	-0.44
11.15863	40.09638	-113.23779	71.24123	-0.74	-0.64	-0.12
11.15890	40.09638	-113.23779	84.59879	-1.01	-0.34	0.03
11.15918	40.09637	-113.23779	98.46066	-1.26	-1.10	-0.75
11.15976	40.09637	-113.23779	128.68462	-1.88	-3.50	-0.52
11.16002	40.09637	-113.23779	143.01363	-1.37	-2.45	1.63
11.16058	40.09637	-113.23779	173.25742	-1.15	-3.14	-1.16
11.16085	40.09637	-113.23779	189.31435	-0.76	-2.13	0.86
11.16421	40.09607	-113.23782	16.99265	0.96	2.95	-0.17
11.16448	40.09607	-113.23782	30.61205	0.60	2.22	-0.42
11.16474	40.09607	-113.23782	43.35239	0.30	2.85	-0.56
11.16558	40.09607	-113.23782	83.66534	-1.12	-1.56	-0.01
11.16586	40.09607	-113.23782	97.08382	-1.11	-0.93	0.04
11.16641	40.09607	-113.23782	124.89384	-1.32	-1.88	0.13
11.16669	40.09607	-113.23782	139.67776	-1.58	-2.00	1.24

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Summary

- A substantial lidar data set was obtained during the MATERHORN-X field campaigns, which contains rich information about the wind field over mountainous terrain.

- Triple lidar work with UND and UU indicated that the combined lidars have the potential to directly measure the large turbulent eddies without any of the assumptions required for dual lidar tower retrieval.

- There are clear advantages of triple lidar compared to towers: they are mobile and can reach much higher altitudes.

- However, to get accurate 3-D wind vector retrieval, the temporal and spatial synchronization between lidars is imperative!

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Planned Further Analysis

- Compare statistics of triple Doppler wind lidar with sonics and other observations when possible.

- Compare the retrieved virtual tower data using triple and dual lidar.

- Study the accuracy of the retrieved winds under different wind conditions (i.e. strong/weak, stable/unstable).

- Determine a criteria for ideal triple lidar virtual tower retrieval (i.e. timing and angle of beam intersections, etc.)

Questions ?

Funded by Air Force Weather Agency (AFWA)