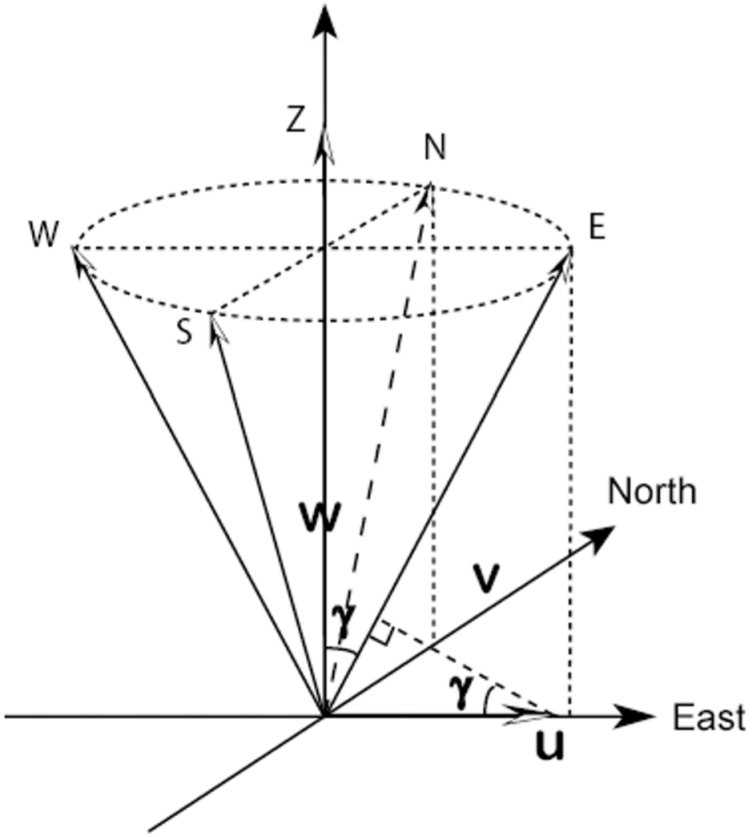
LIDAR BENEFITS

- Low-level radar data can be messy…even in the Plains.
- Vertical velocity only possible with a third radar or integration of continuity equation.
- Clear-air data tough to acquire even for "sensitive" systems.

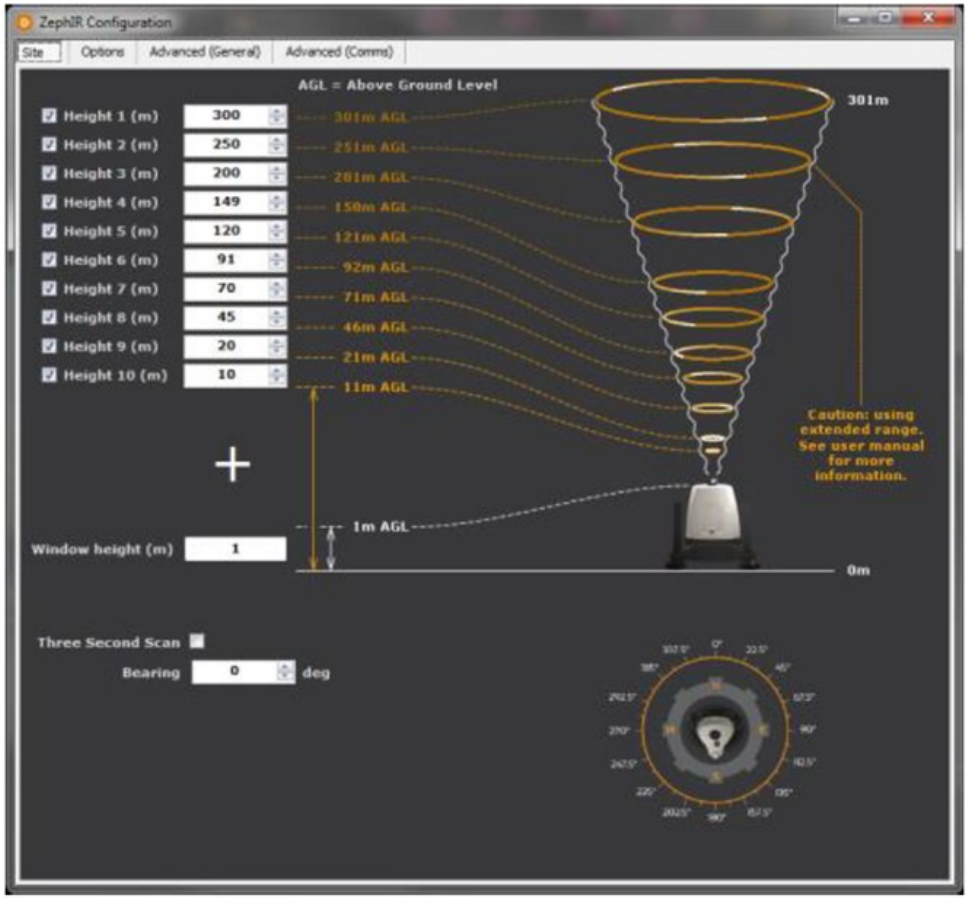
PROFILING LIDAR TYPES

- Pulsed lidar
  - WindCube
  - Uses a modified Doppler Beam Swinging (DBS) technique
  - 5 beams emitted simultaneously.
  - Lowest level is 40 m
  - ~ 30 m range gate spacing; ~ 4 secs for full profile



PROFILING LIDAR TYPES

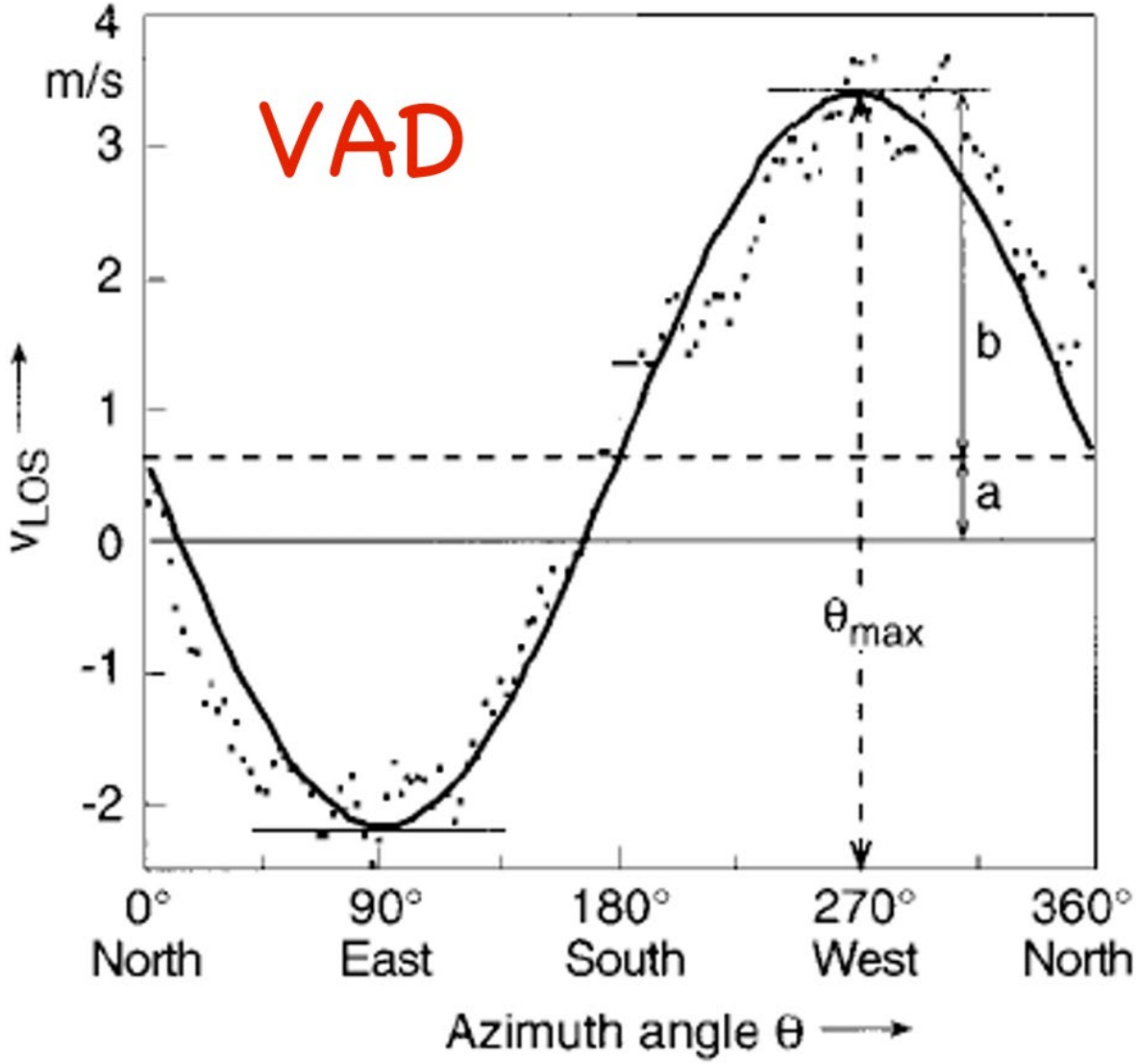
- Continuous Wave:
  - Prism performs a complete 360 for each level.
  - The VAD technique is used to get a wind speed / direction for a given level.
  - Variable range gates; ~15 sec scans.
  - Allows for data collection as low as 10 m.
  - Requires surface measurement for initial WD guess.

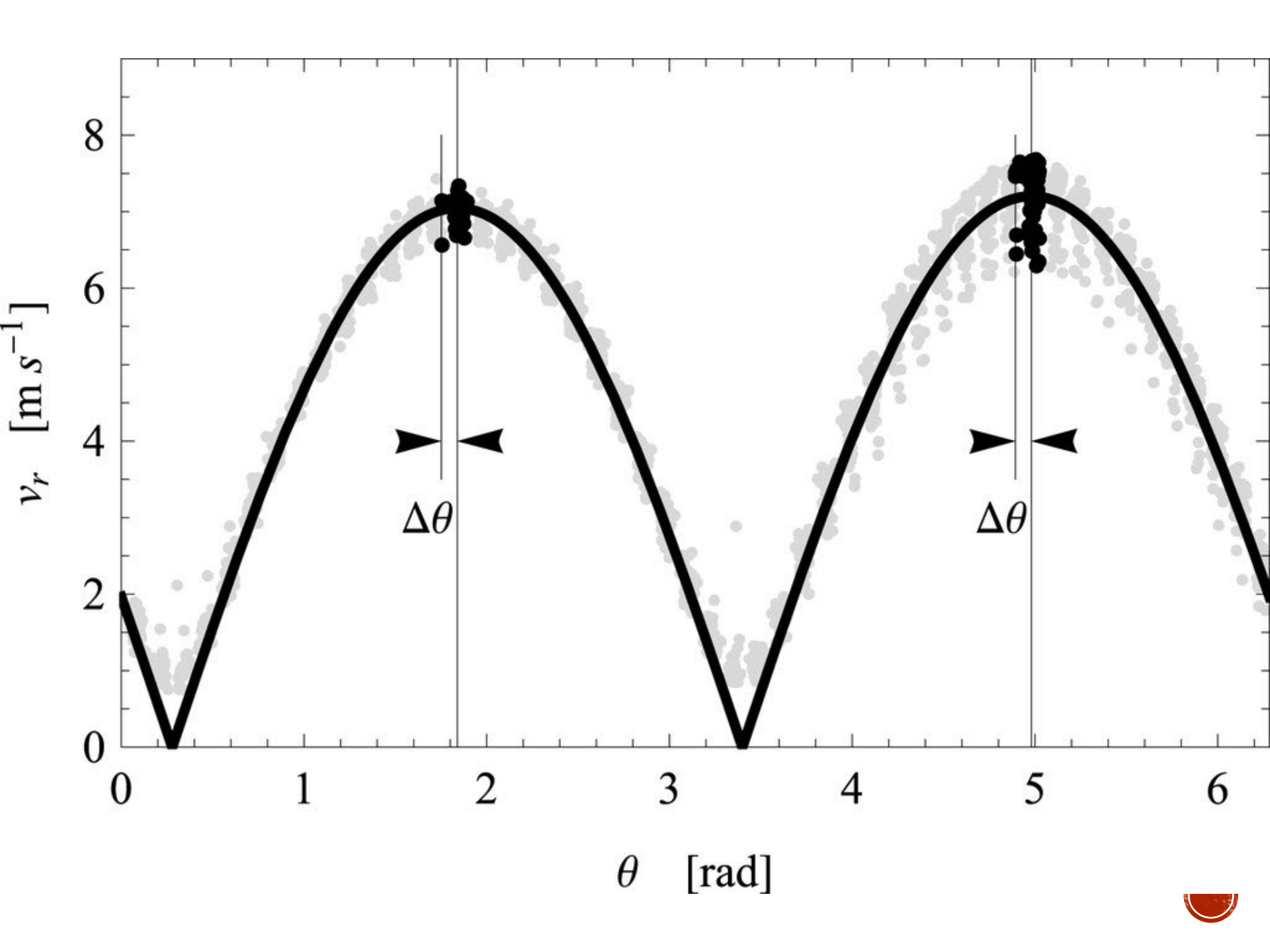


PROFILING LIDAR

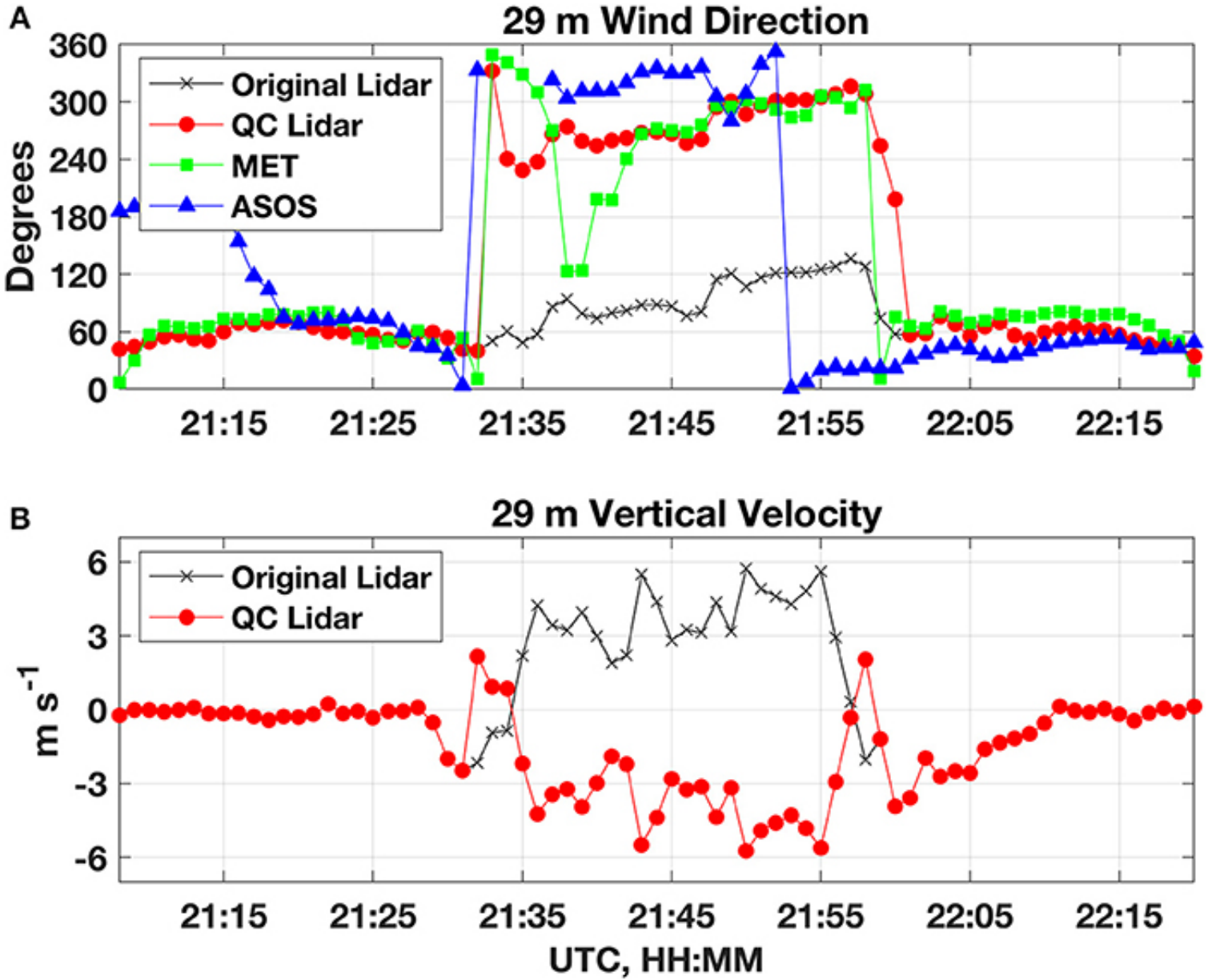
- ZyphIR 300 Profiling Lidar
- 10 heights between 29 m and 143 m.
- WS, WD and Vertical Velocity within each height bin.
- Rigorous testing has classified these units as “bankable”.

PROFILING LIDAR TYPES

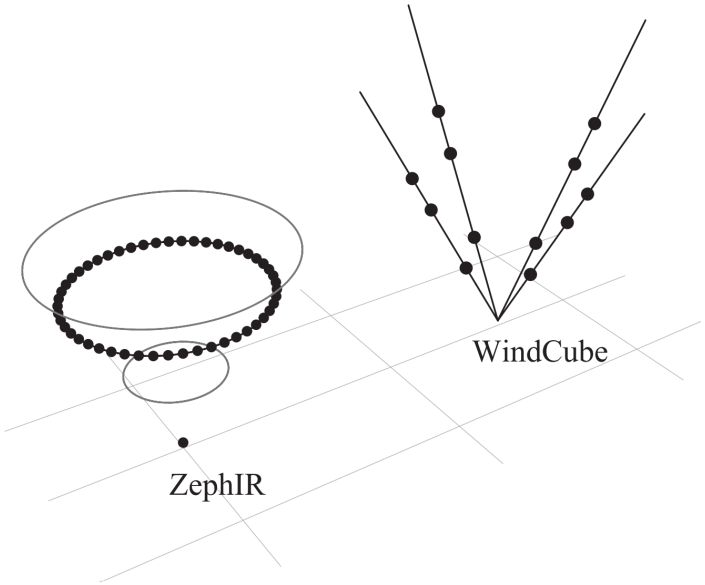


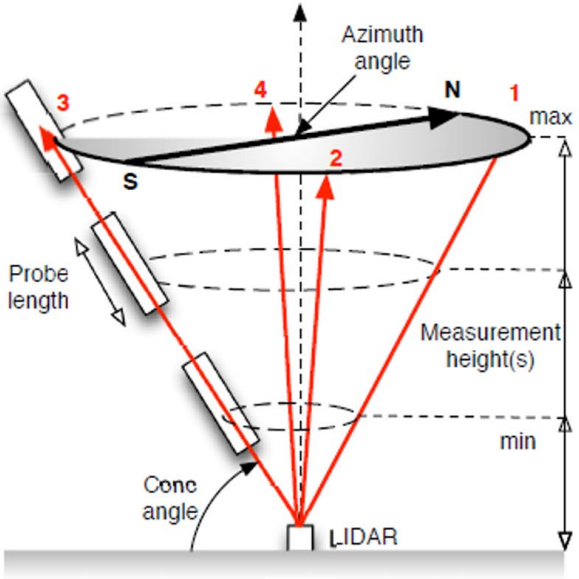

8
6
4
2
0
v_r [m s^{-1}]
$\Delta\theta$
$\Delta\theta$
0
1
2
3
4
5
6
θ [rad]

PROFILING LIDAR TYPES

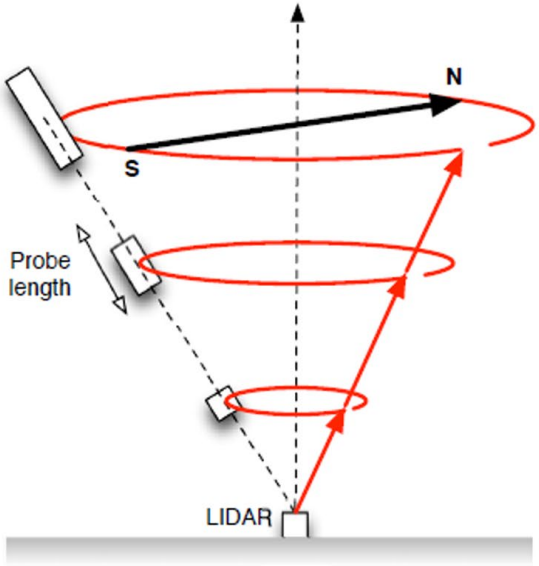


PROFILING LIDAR TYPES



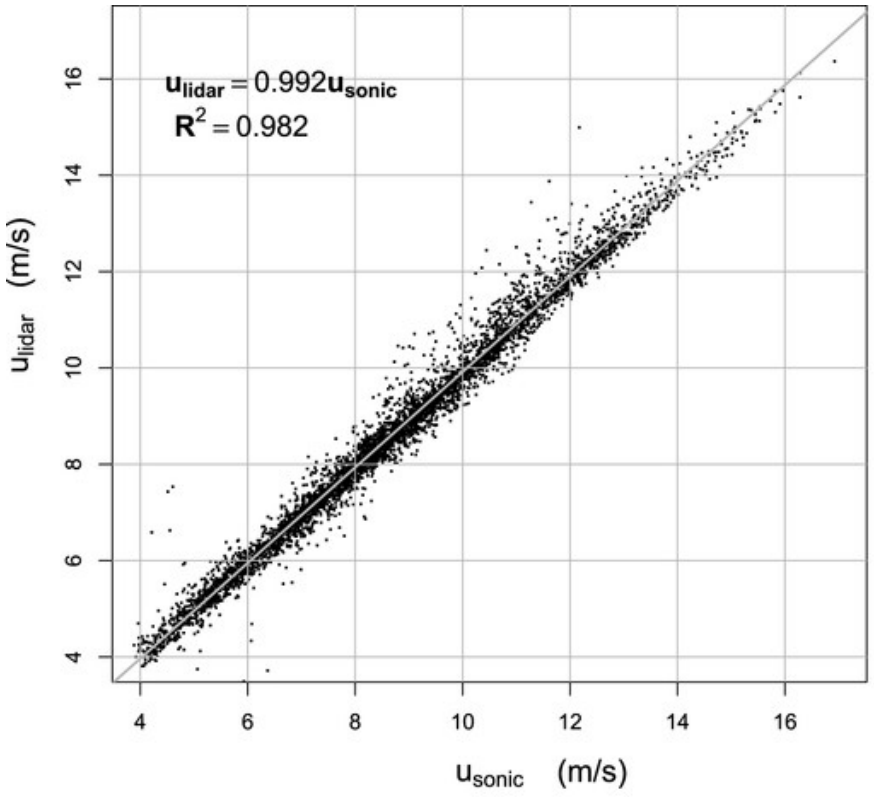


(a) Pulsed DBS lidar

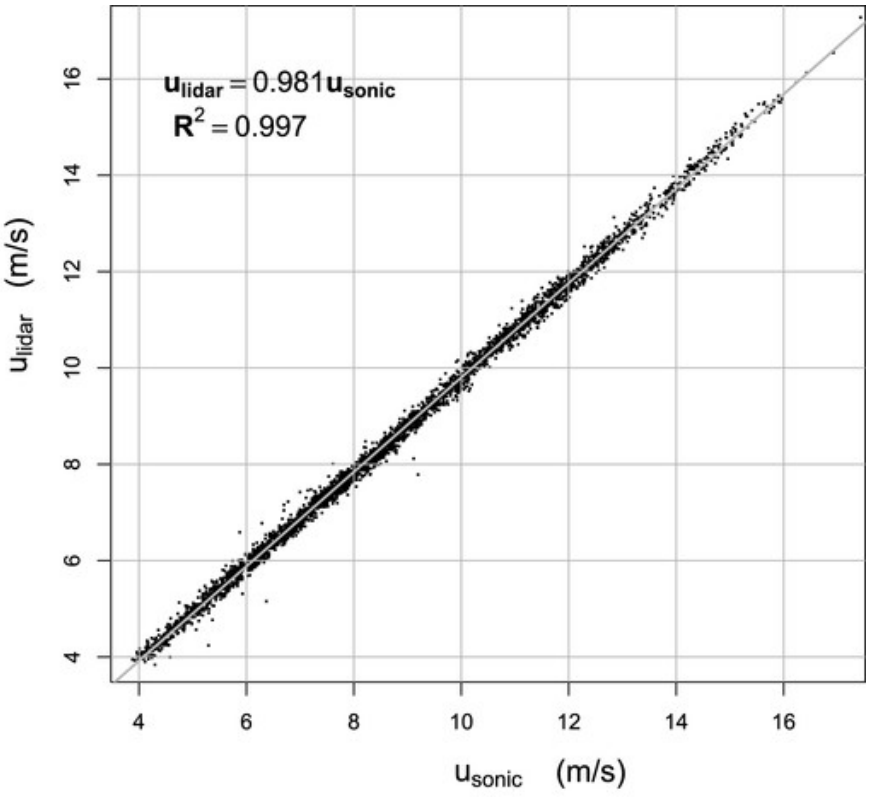


(b) Continuous Wave VAD lidar

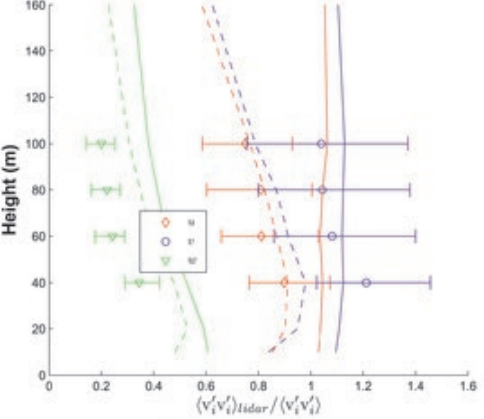
PROFILING LIDAR TYPES



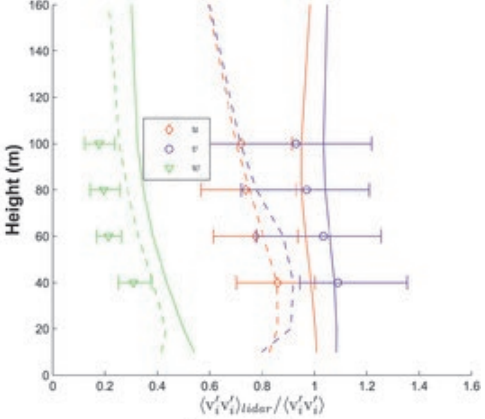
(a) ZephIR



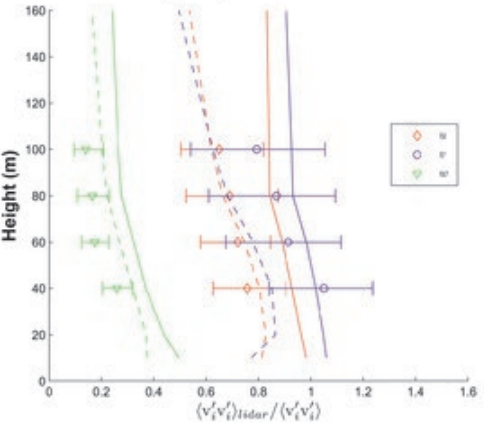
(b) WindCube



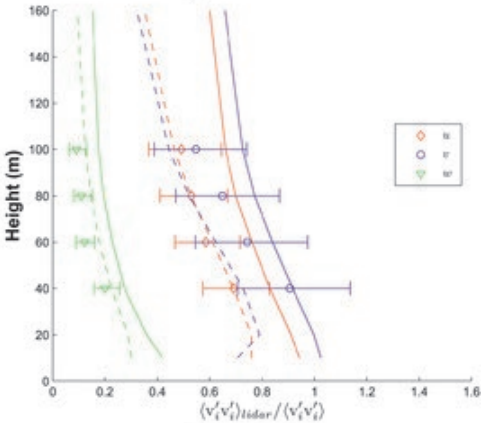
(a) very unstable



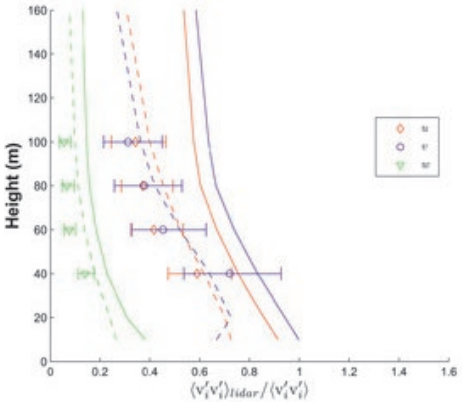
(b) unstable



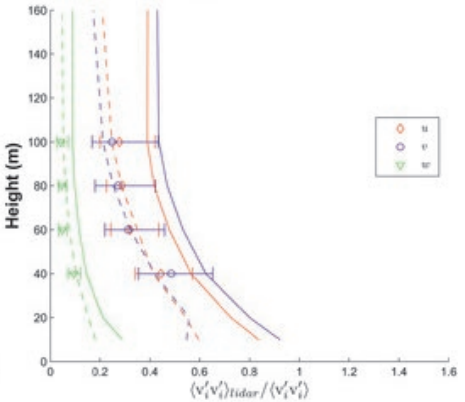
(c) near neutral unstable



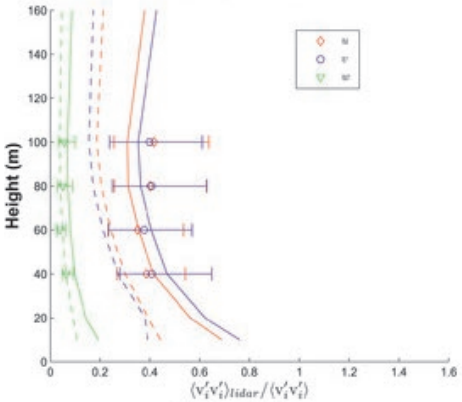
(d) neutral



(e) near neutral stable



(f) stable



(g) very stable

OTHER LIDAR TYPES

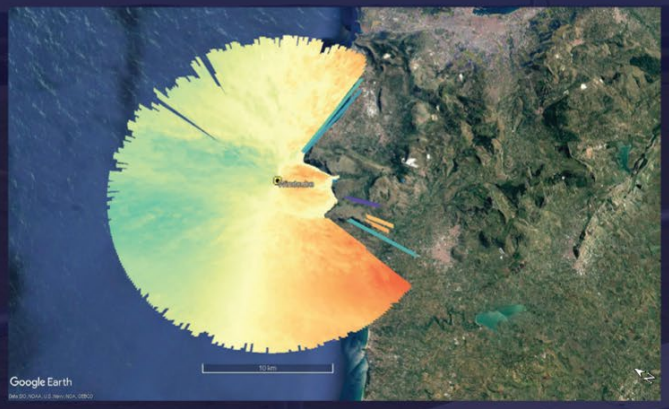
- Scanning Wind lidar

How scanning lidar works

Like a vertical profile lidar, scanning lidar uses laser pulses that are sent into the atmosphere and reflected by aerosols or particulates traveling within it. When the light is backscattered and returned to the lidar unit, the Doppler shift can be calculated, providing an accurate wind speed measurement.

Unlike vertical profilers, however, scanning lidar units measure across 360° using several scanning patterns, up to ranges of 15km and beyond in the case of Leosphere's WindCube® Scan, which is covered in detail later.

This provides 3D spatial wind awareness and, among other benefits, allows operators to assess several turbines at once. This creates enormous efficiency, increases wind assessment certainty, and improves both the quality and the quantity of available wind data.



Leosphere
A VAISALA COMPANY

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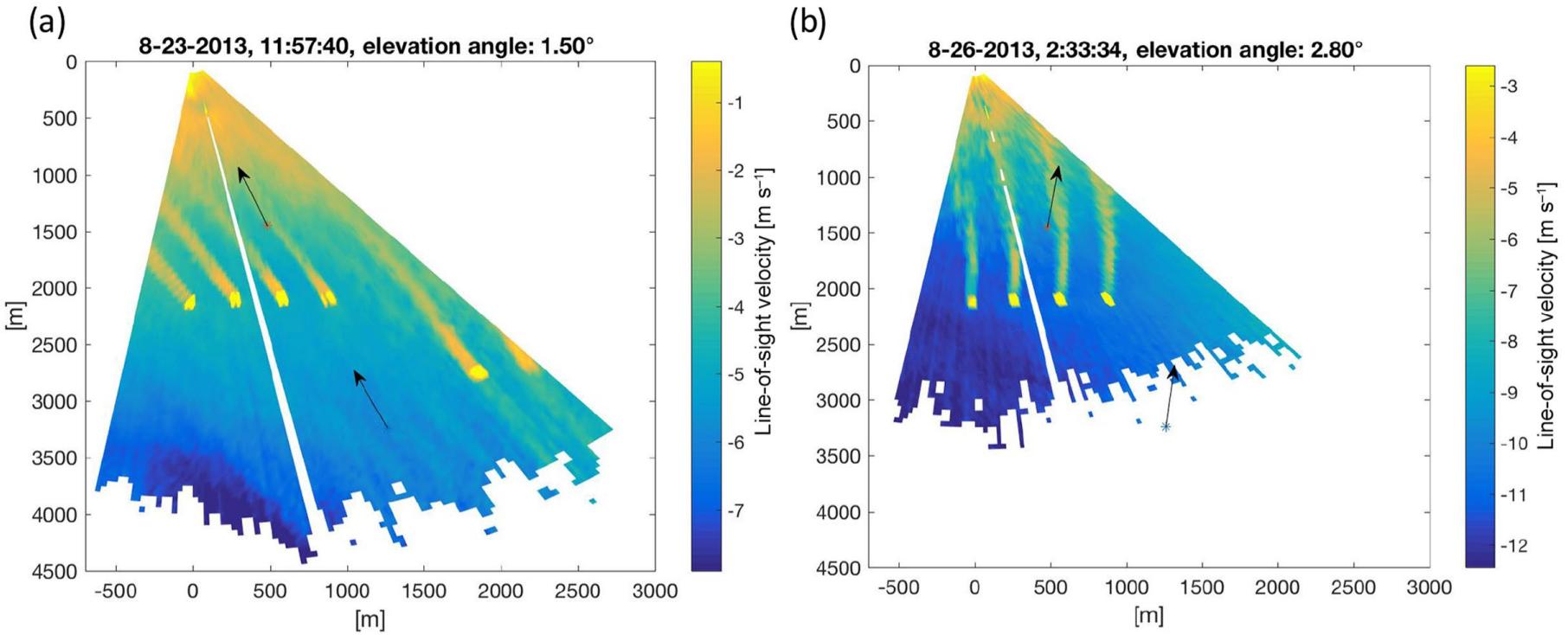
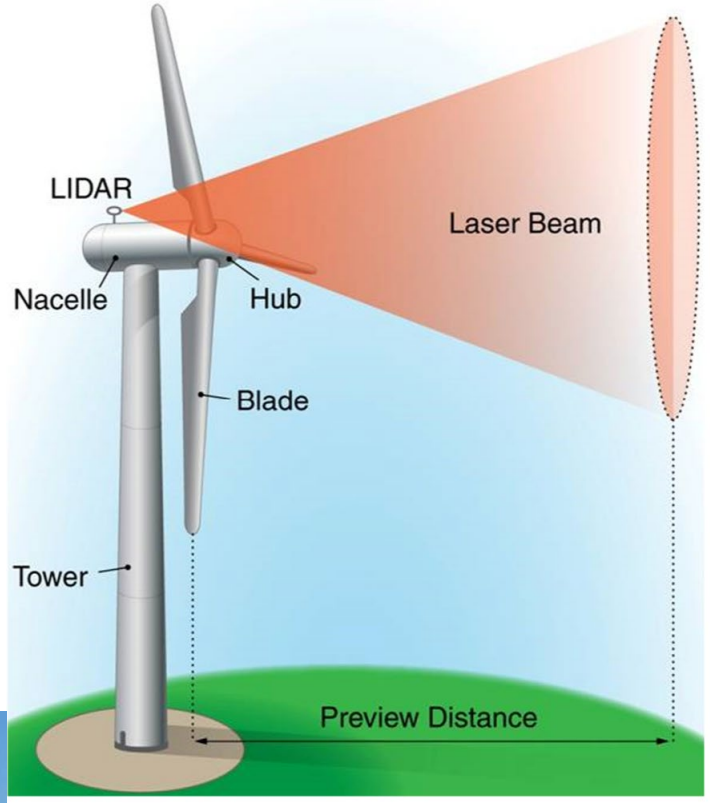
OTHER LIDAR TYPES

- Scanning Wind lidar

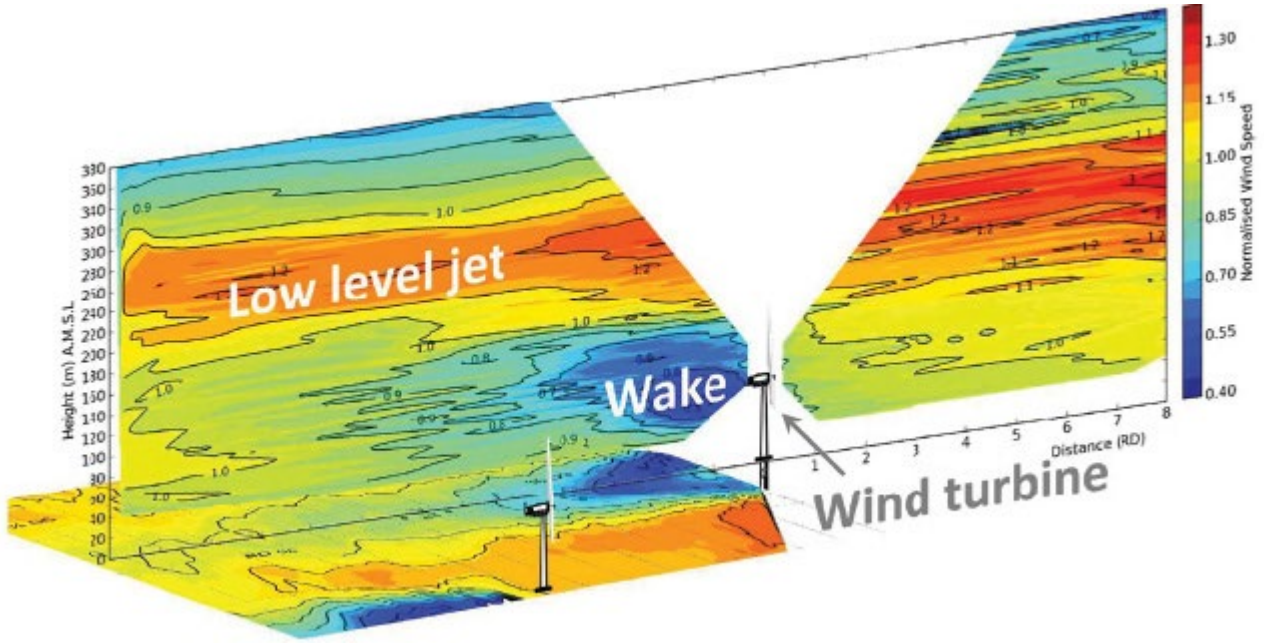


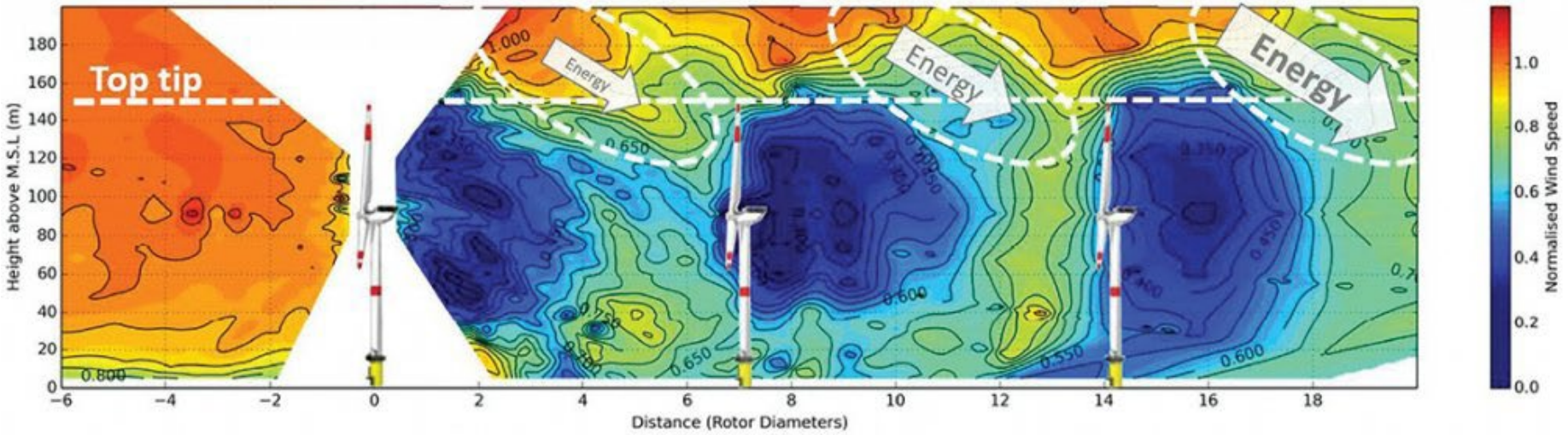
OTHER LIDAR TYPES

- Nacelle Mounted Lidars
  - "look ahead"
  - Mostly used for turbine control and wake ID



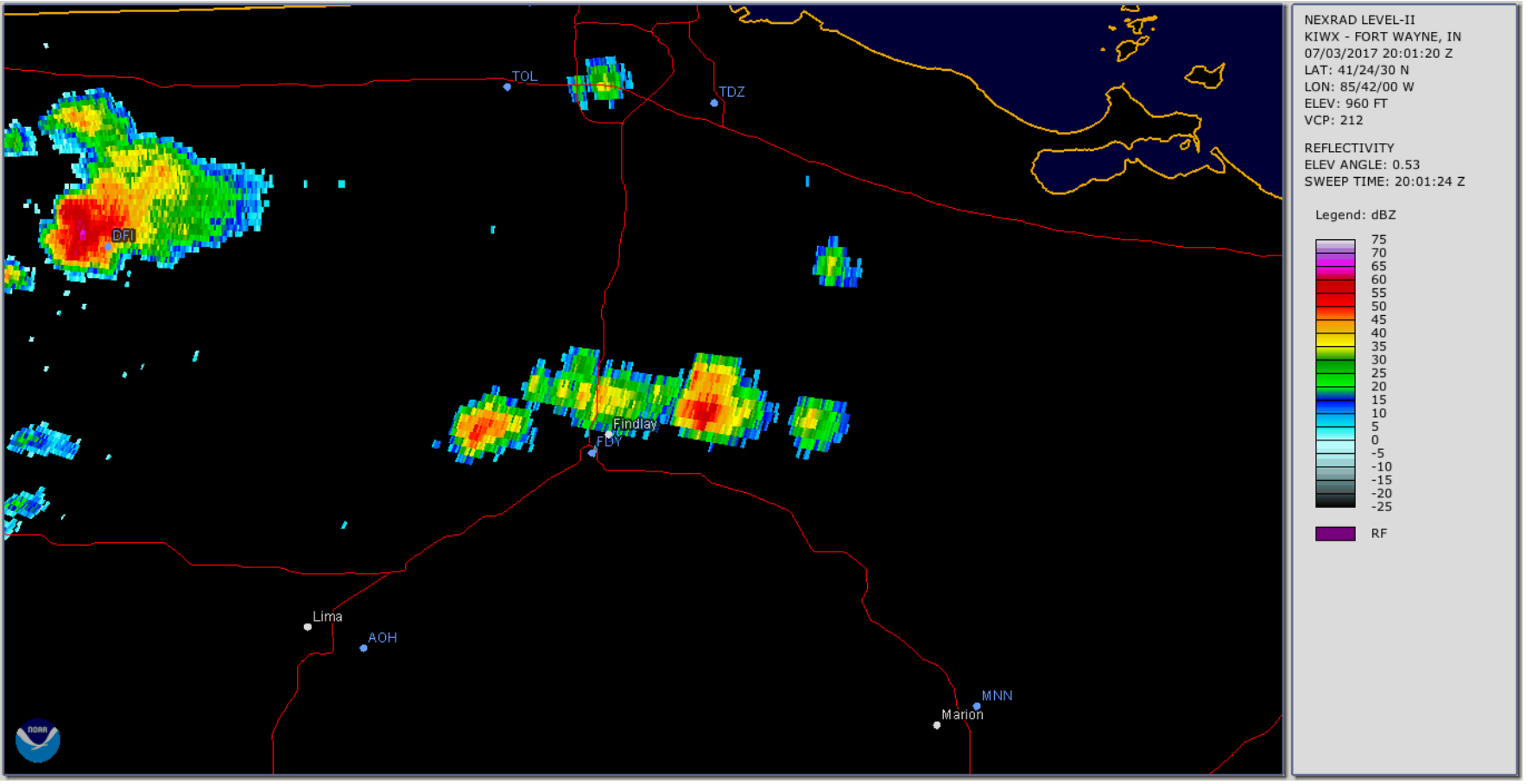
OTHER LIDAR TYPES



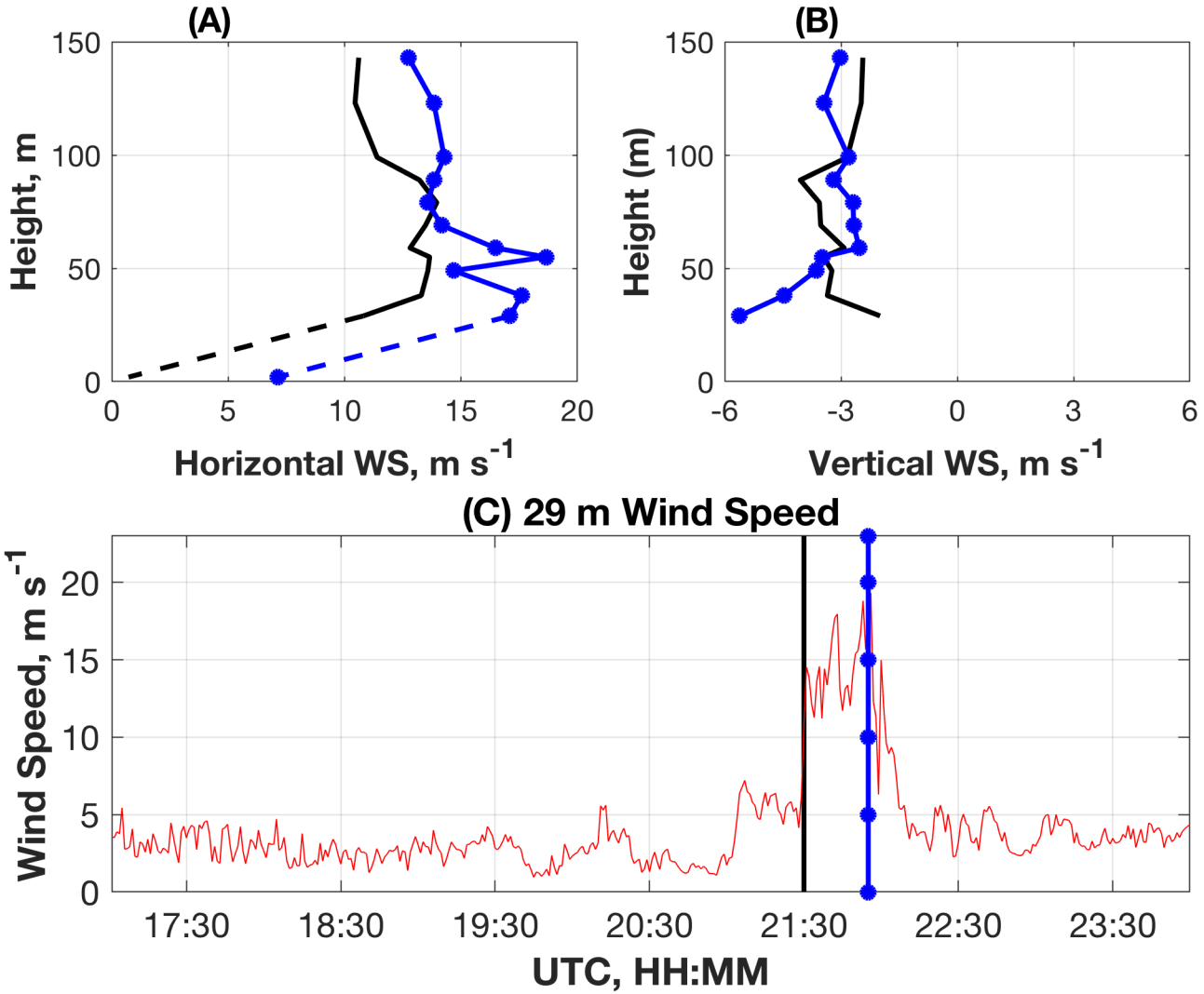


LIDAR DATA CASE STUDY

- Analyzed several "pulse" thunderstorm types from July 2017



LIDAR CASE STUDY



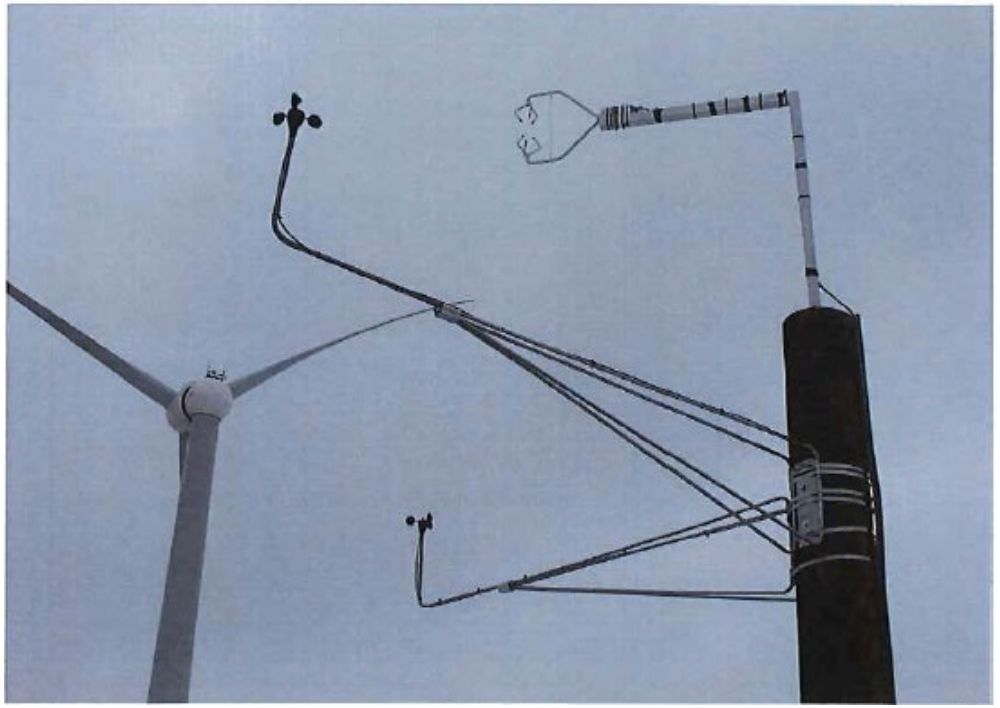
MEASUREMENT COMPARISONS

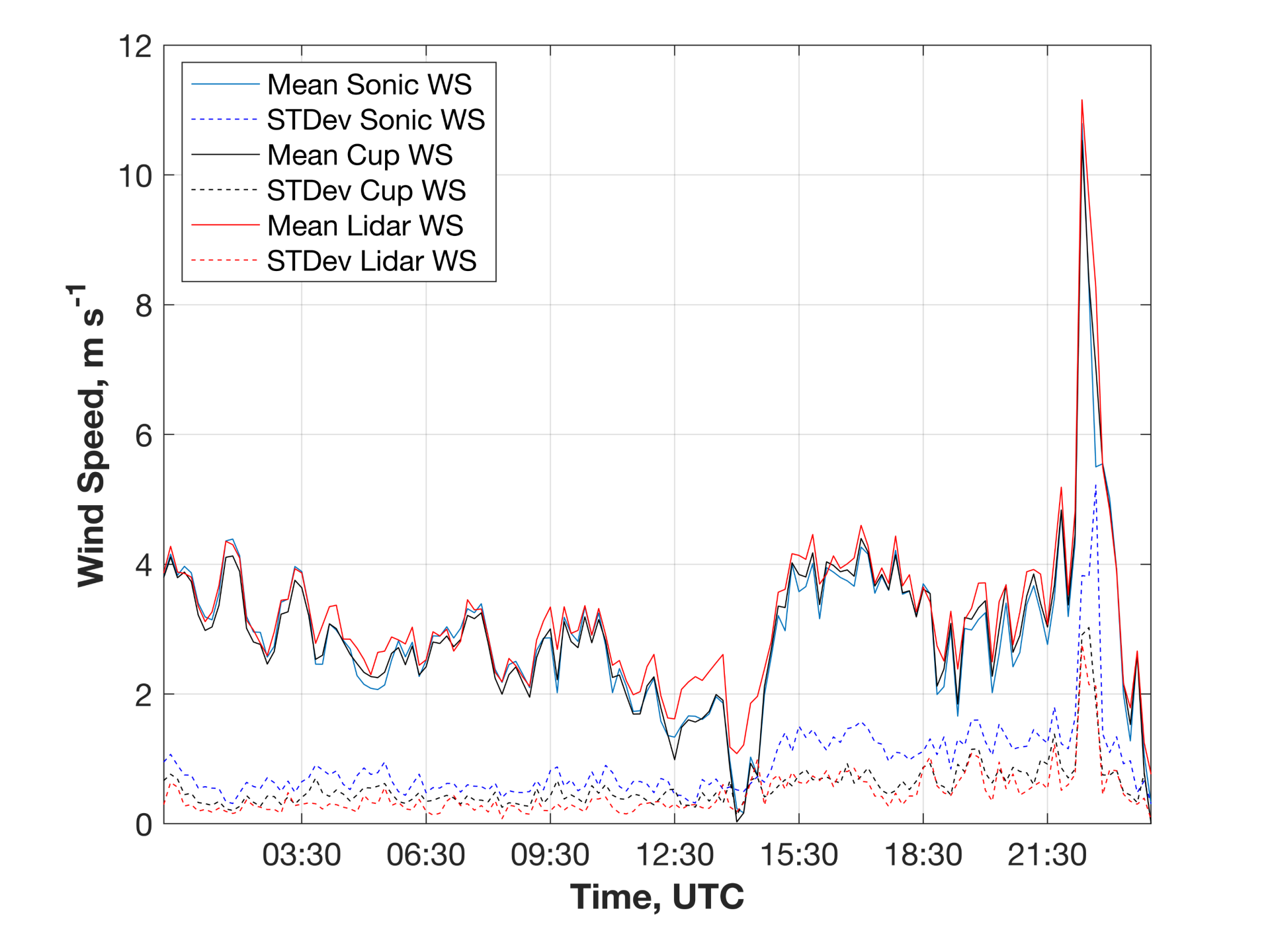
- New techniques should be verified with proven methods.

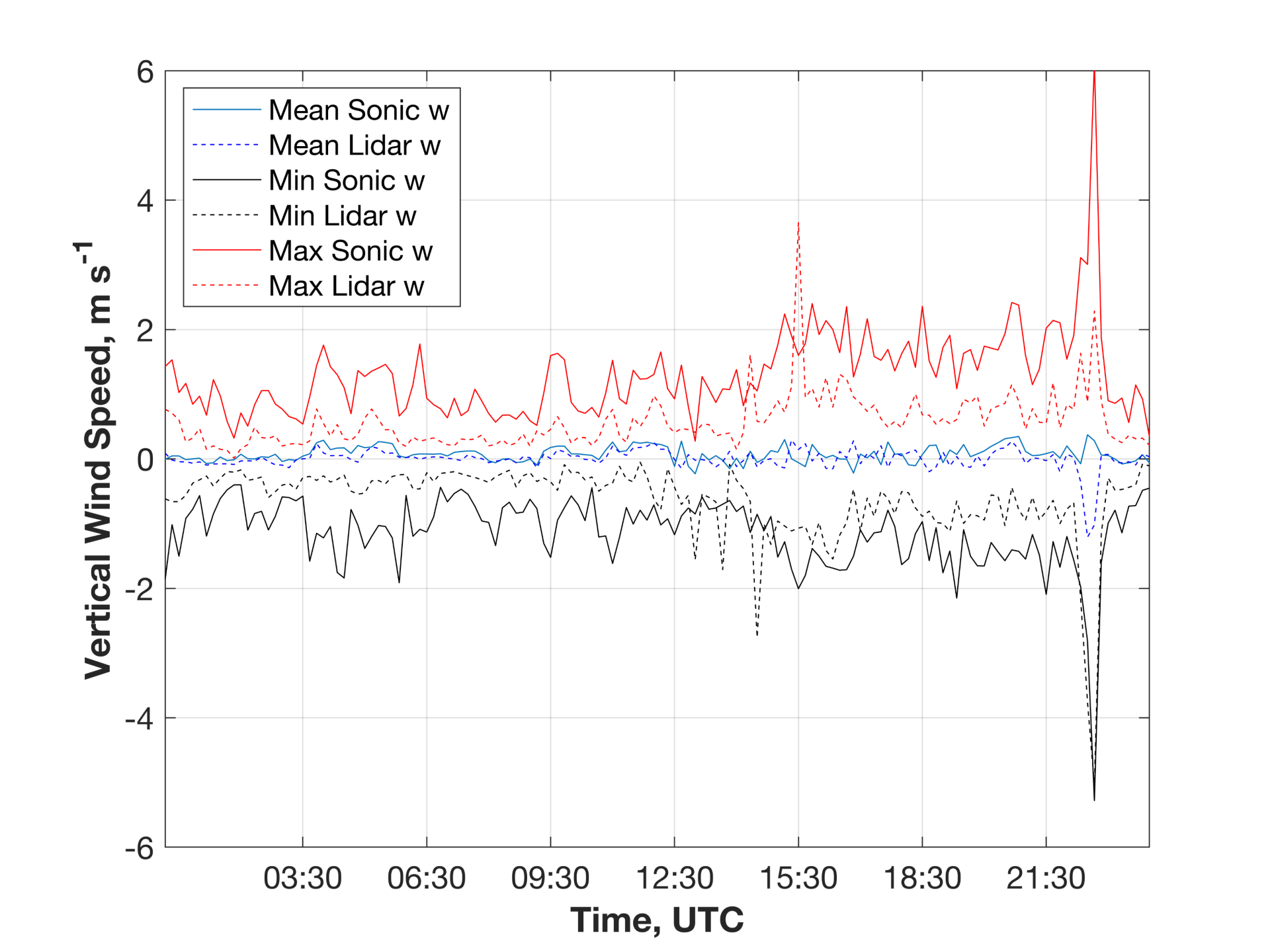
- "Proven" methods for measuring wind generally include some type of anemometer.

LIDAR CASE STUDY

- Compare to lidar data to anemometers data.
- 2 NRG 40C cup anemometers (scalar wind speed)
  - 28 m AGL
- 2 NRG wind vanes
  - 25 m AGL
- CSATB Sonic
  - 30 m AGL
  - U,V, and W
- 10 min. Statistics




Mean Sonic WS
STDev Sonic WS
Mean Cup WS
STDev Cup WS
Mean Lidar WS
STDev Lidar WS
Wind Speed, m s-1
0
2
4
6
8
10
12
03:30
06:30
09:30
12:30
15:30
18:30
21:30
Time, UTC


Mean Sonic w
Mean Lidar w
Min Sonic w
Min Lidar w
Max Sonic w
Max Lidar w
Vertical Wind Speed, m s-1
6
4
2
0
-2
-4
-6
03:30
06:30
09:30
12:30
15:30
18:30
21:30
Time, UTC

RESULTS

- "Volume" averaging smooths smaller scales of turbulence in both radar and lidar data.
- ZyphIR Lidar performed well in moderate to heavy precipitation.
- Hydrometer fall-speeds likely influenced vertical velocity estimation in lidar data.