



*Supplement of*

## **Emerging mobile lidar technology to study boundary layer winds influenced by operating turbines**

**Yelena Pichugina et al.**

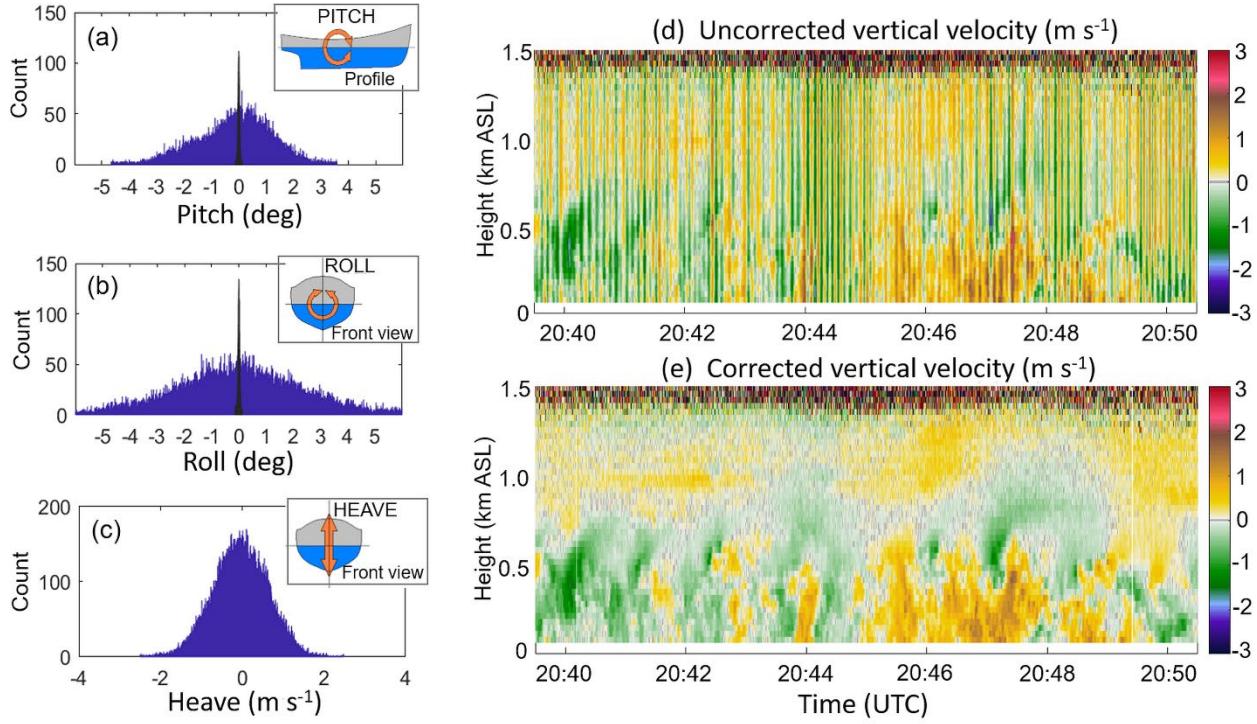
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1    **Supplemental materials**

2    ***S1. Sample of active stabilization of the ship-based lidar***

3        At sea, active stabilization and pointing correction, implemented in the mobile lidar system,  
4        compensates for ship motions (pitch, roll, and heave) and allows measurements to be obtained of  
5        the vertical velocity without mixing in the projection of the horizontal wind speeds and their  
6        variation (Fig. S1). The pointing stabilization is achieved by real-time monitoring of platform and  
7        lidar pitch and roll, with the lidar head mounted in a motorized frame that provides pitch and roll  
8        counter to the platform. Correction of the vertical beam pointing for the pitch motions (Fig. S1a)  
9        reduced the standard deviation away from zenith from  $1.17 \text{ m s}^{-1}$  to  $0.03 \text{ m s}^{-1}$ . Similarly, correction  
10      for the roll motions (Fig. S1b) decreases standard deviation from  $2.10 \text{ m s}^{-1}$  to  $0.03 \text{ m s}^{-1}$ . The  
11      variance ( $0.2 \text{ m}^2 \text{ s}^{-2}$ ) of the heave platform motion (Fig. S1c) was removed from the calculated wind  
12      variance profile. A sample of the uncorrected and corrected vertical velocity is shown in Fig. S1d  
13      and e. Overall, during offshore measurements, the vertical velocity profiles were obtained with the  
14      precision  $<0.06^\circ$  root-mean-square due to pointing stabilization and with an accuracy  $\approx 0.15^\circ$ . The  
15      motion compensation allowed the calculation and removal of platform motions from vertical  
16      velocity profiles with  $1^\circ$ – $2^\circ$  RMS in pitch, roll, and with  $\pm 1$ – $2 \text{ m s}^{-1}$  vertical error due to the heave  
17      motions.



18

19 Figure S1. A sample of the ship-motion correction vertical velocity measurements from the Tradewind  
 20 Ocean-Atmosphere Interaction Campaign (ATOMIC) in Western Atlantic. (a–c) Distributions of ship  
 21 motions (pitch, roll, and heave) during vertical velocity measurements are shown by the blue color. The  
 22 black color shows stabilized motions of the lidar (a, b). A sample of (d) uncorrected and (e) corrected vertical  
 23 velocity measurements on Jan. 20., 2020.

24

25 Continuous profiling from a month-long campaign in the Western Atlantic are used us to  
 26 obtain highly accurate profiles of the range-corrected intensity, wind speed, wind direction, and  
 27 vertical velocity statistics, including variance, skewness, kurtosis, and compute integral length  
 28 scale, turbulence kinetic energy dissipation rate, mass flux, probability density function (PDF) of  
 29 vertical velocity, and plume size PDF.

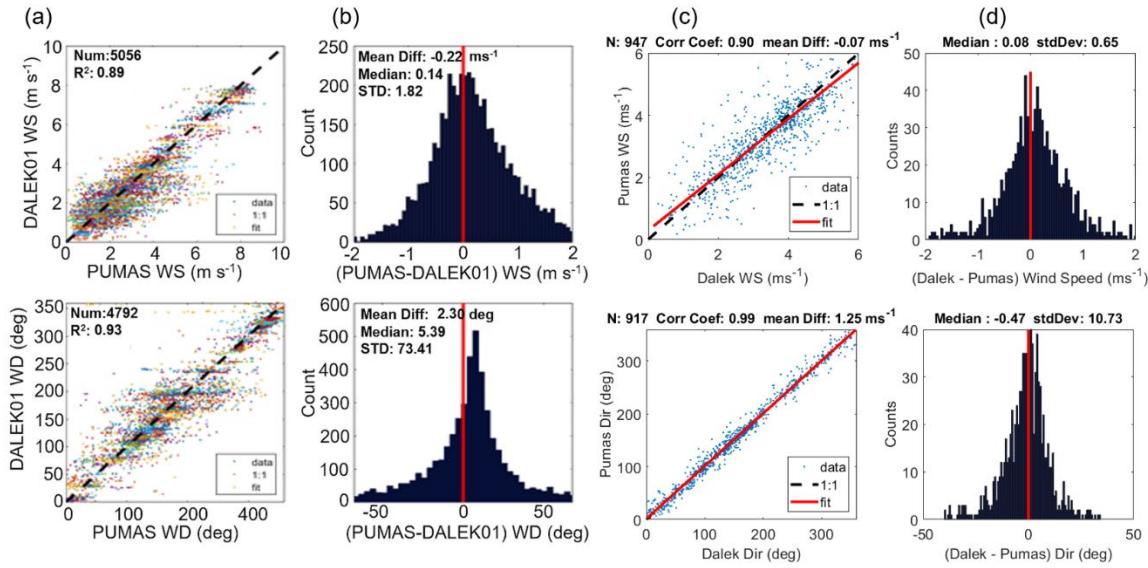
30 This example clearly illustrates success in developing a fully capable mobile Doppler lidar that  
 31 provides accurate measurements compensated for the ship's motions.

32

33 ***S2. Evaluation of the accuracy of PUMAS and stationary Doppler lidar measurements of the***  
 34 ***horizontal wind speed and direction.***

35 Similar to the estimates of the accuracy of MD measurements from a large, slow-moving  
 36 ship platform, the measurements from aircraft- and truck-based platforms were compared to the  
 37 stationary Doppler lidar measurements during various field campaigns utilizing both types, mobile

38 and stationary lidars. The high correlation coefficients were found for wind speed ( $R^2 = 0.89$ ) and  
 39 wind direction ( $R^2 = 0.92$ ) from PUMAS mobile measurements and stationary ground-based lidars  
 40 during the SUNVEx (Fig. S2a, b). Comparison of data from PUMAS and LEOSPHERE 200S  
 41 Doppler lidar both stationed at the David Skaggs Research Center located in Boulder, Colorado,  
 42 show high correlation for wind speed ( $R^2 = 0.90$ ) and direction ( $R^2 = 0.99$ ) with very small  
 43 differences between data (Fig. S2c, d).



44  
 45 Fig. S2 Validating mobile Doppler lidar measurements: (a, b) Comparing data from mobile (PUMAS) and  
 46 stationary (DALEK01) scanning Doppler lidars during SUNVEx field measurements. Data from mobile  
 47 lidar are taken within 2.5 km of the stationary LEOSPHERE 200S lidar; (c, d) Static offset check. PUMAS  
 48 profiles averaged over 20 minutes and compared to LEOSPHERE 200S.