Validation of Aeolus L2B products in the lower troposphere by a ground-based CDL network over China

Songhua Wu[1,2,3], Kangwen Sun[1], Guangyao Dai[1], Xiaoye Wang[1], Xiaoying Liu[1], Bingyi Liu[1,2], Xiaoquan Song[1,3], Oliver Reitebuch[4]

[1] College of Marine Technology, Faculty of Information Science and Engineering, Ocean University of China, Qingdao, 266100, China

[2] Laboratory for Regional Oceanography and Numerical Modelling, Pilot National Laboratory for Marine Science and Technology (Qingdao), Qingdao, 266200, China

[3] Institute for Advanced Ocean Study, Ocean University of China, Qingdao, 266100, China

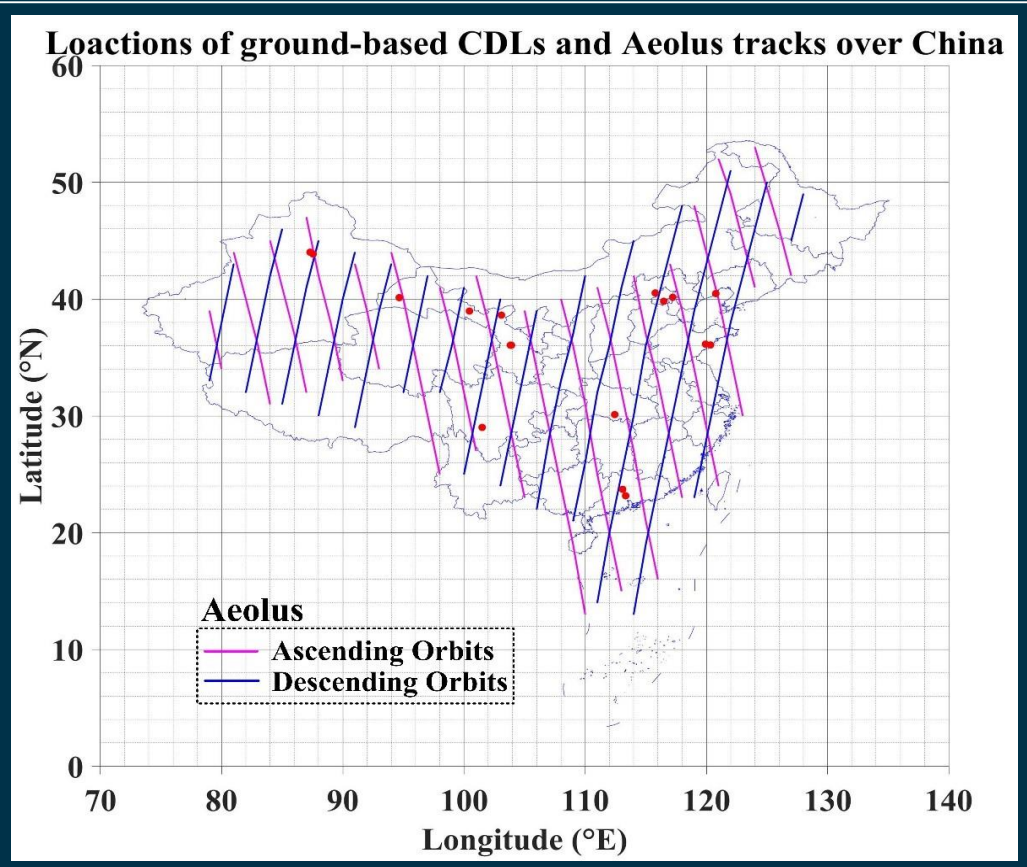
[4] German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt e.V., DLR), Institute of Atmospheric Physics, Oberpfaffenhofen, 82234, Germany

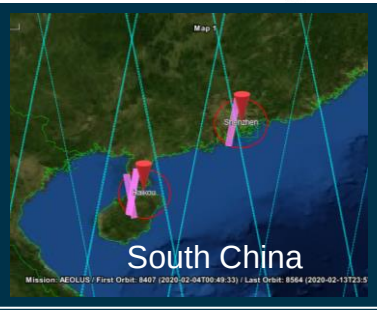
3rd Aeolus NWP Impact and L2B product quality working meeting, Webex, 1 December 2021

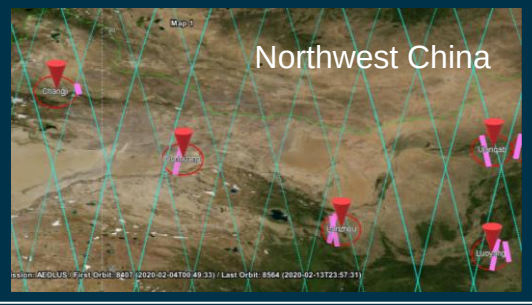
Topics

- Overview of the validation campaigns (VAL-OUC)
- Ground-based Coherent Doppler wind lidar (CDL)
- Inter-comparison strategy and quality control
- Influence of vertical velocity on V_{HLOS}
- Measurement cases over China
- Statistical comparison

Overview of the validation campaigns (VAL-OUC)







from January to December 2020

Location	Latitude, Longitude, Altitude	Measurement period	Instrument type	Measurement mode
Dunhuang	40.12°N, 94.66°E 1.15 km	From 07 Jan. 2020 to 29 Dec. 2020	WindMast PBL	DBS
Lanzhou	36.05°N, 103.91°E 1.51 km	From 07 Jan. 2020 to 29 Dec. 2020	WindMast PBL	DBS
Zhangye	38.97°N, 100.45°E 1.46 km	From 05 Jan. 2020 to 27 Dec. 2020	WindMast PBL	DBS
Jingzhou	30.11°N, 112.44°E 0.03 km	From 24 June 2020 to 22 July 2020	Wind3D 6000	DBS
Pinggu, Beijing	40.15°N, 117.22°E 0.05 km	From 21 Apr. 2020 to 02 June 2020	Wind3D 6000	DBS
Changji	44.01°N, 87.30°E 0.58 km	03 Dec. 2020	Wind3D 6000	DBS
Jiulong, Sichuan	29.01°N, 101.50°E 2.90 km	From 24 Oct. 2020 to 29 Nov. 2020	Wind3D 6000	DBS
Jiaozhou, Shandong	36.14°N, 119.93°E 0.02 km	21 Dec. 2020	Wind3D 6000	DBS
Qingyuan, Guangdong	23.71°N, 113.09°E 0.03 km	From 12 May 2020 to 27 Aug. 2020	Wind3D 6000	DBS
Xidazhuangke, Beijing	40.52°N, 115.78°E 0.91 km	From 7 Jan. 2020 to 31 Mar. 2020	Wind3D 6000	DBS
Yizhuang, Beijing	39.81°N, 116.48°E 0.04 km	From 07 Apr. 2020 to 25 Aug. 2020	Wind3D 6000	DBS
Huludao	40.47°N, 120.78°E 0.10 km	From 01 Nov. 2020 to 28 Dec. 2020	Wind3D 6000	DBS
Wuwei	38.62°N, 103.09°E 1.37 km	From 11 Apr. 2020 to 26 Dec. 2020	Wind3D 6000	DBS
Lanzhou	36.05°N, 103.83°E 1.53 km	From 04 Jan. 2020 to 26 Dec. 2020	Wind3D 6000	DBS
South China University of Technology	23.16°N, 113.34°E 0.03 km	From 13 Oct. 2020 to 29 Dec. 2020	Wind3D 6000	DBS
Urumqi	43.85°N, 87.55°E 0.84 km	From 14 Oct. 2020 to 24 Dec. 2020	Wind3D 6000	DBS
Qingdao	36.07°N, 120.34°E 0.04 km	From 02 Nov. 2020 to 28 Dec. 2020	Wind3D 6000	DBS

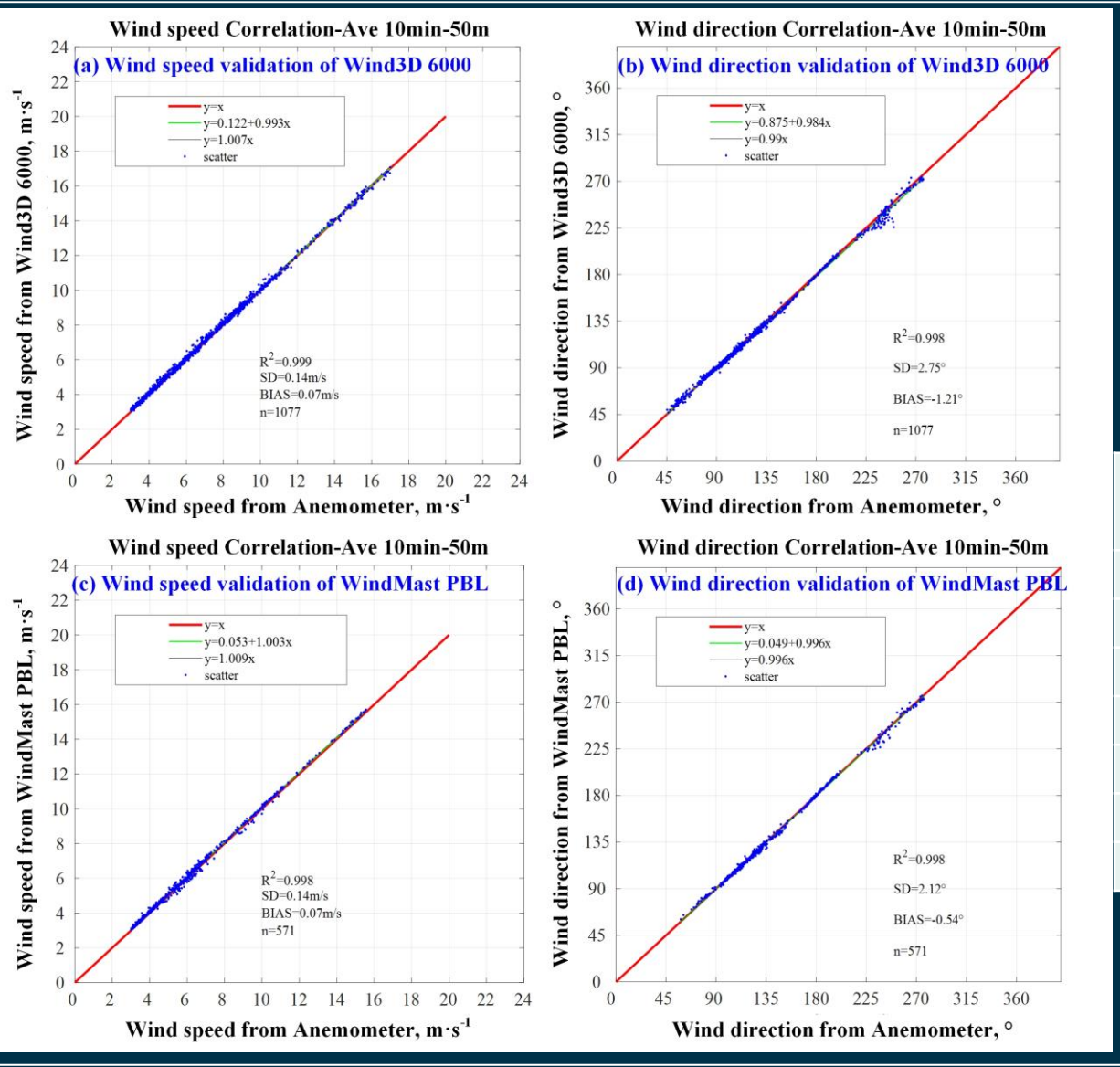
Ground-based Coherent Doppler wind lidar (CDL)

☐ Specifications of 3D scanning PCDL (Wind3D 6000/WindMast PBL)

Qualification	Specifications	
	Wind3D 6000	WindMast PBL
Wavelength	1550 nm	1550 nm
Repetition rate	10 kHz	10 kHz
Pulse energy	160 µJ	100 µJ
Pulse width	100 ns to 400 ns	100 ns to 400 ns
Detection range	**80 m to 6000 m**	**30 m to 4000 m**
Data update rate	4 Hz	4 Hz
Range resolution	15 m to 60 m	15 m to 30 m
Wind speed accuracy	**≤0.1 m/s**	**≤0.1 m/s**
Wind speed range	**±75 m/s**	**±75 m/s**
Wind direction accuracy	0.1°	0.1°

Ground-based Coherent Doppler wind lidar (CDL)

Validation with mast

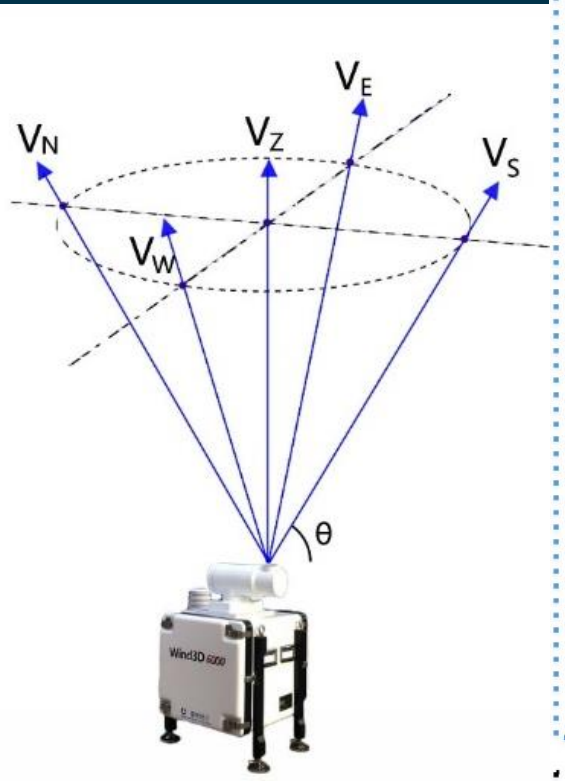


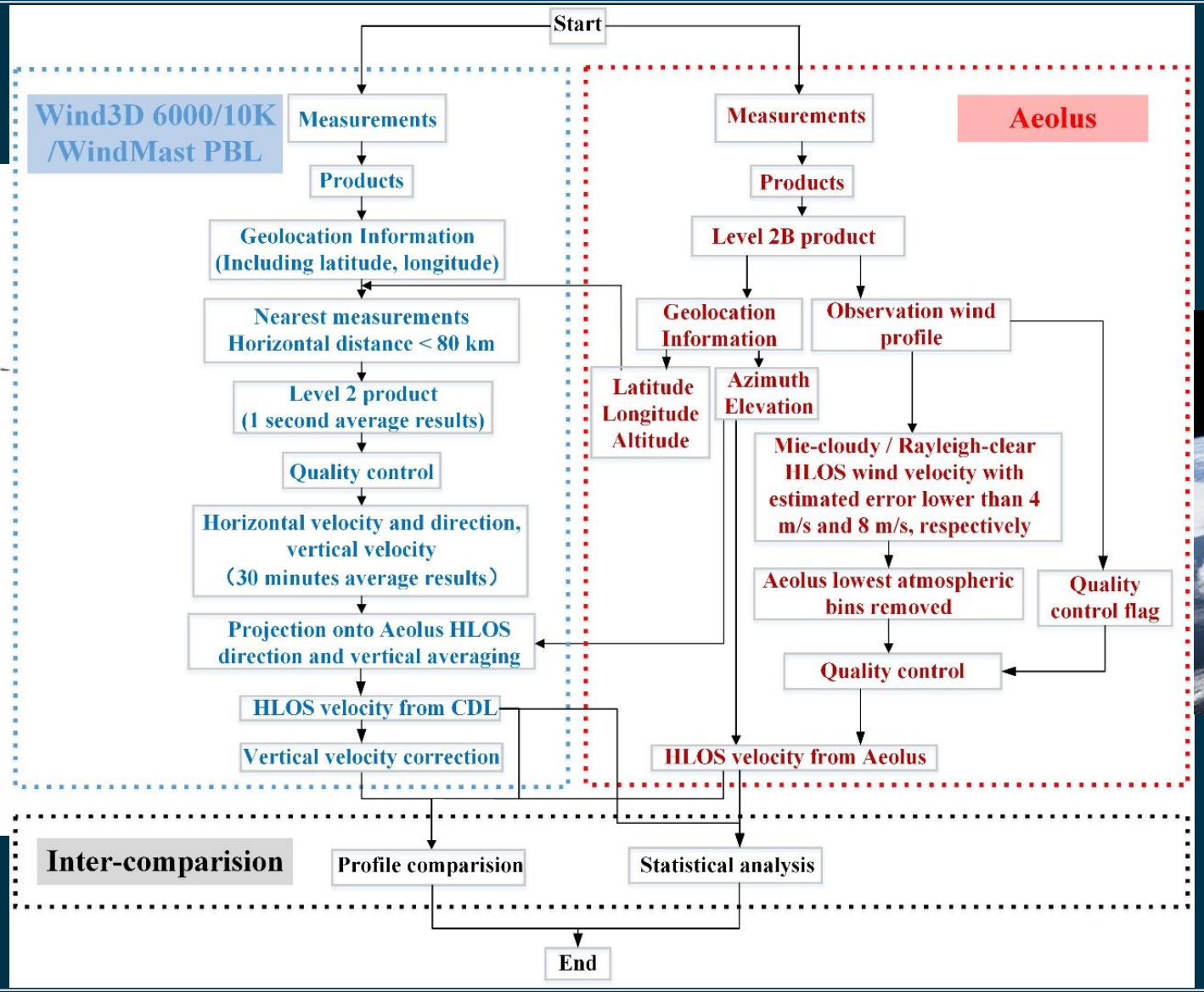
Specifications	Wind speed from Wind3D 6000	Wind direction from Wind3D 6000	Wind speed from WindMast PBL	Wind direction from WindMast PBL
N points	1077	1077	571	571
Correlation	**0.999**	**0.998**	**0.998**	**0.998**
SD	**0.14 (m/s)**	**2.75 (°)**	**0.14 (m/s)**	**2.12 (°)**
BIAS	**0.07 (m/s)**	**-1.21 (°)**	**0.07 (m/s)**	**-0.54 (°)**
“y=ax” Slope	1.007	0.99	1.009	0.996
“y=ax+b” Slope	0.993	0.984	1.003	0.996
“y=ax+b” Intercept	0.122 (m/s)	0.875 (°)	0.053 (m/s)	0.049 (°)

Hence:

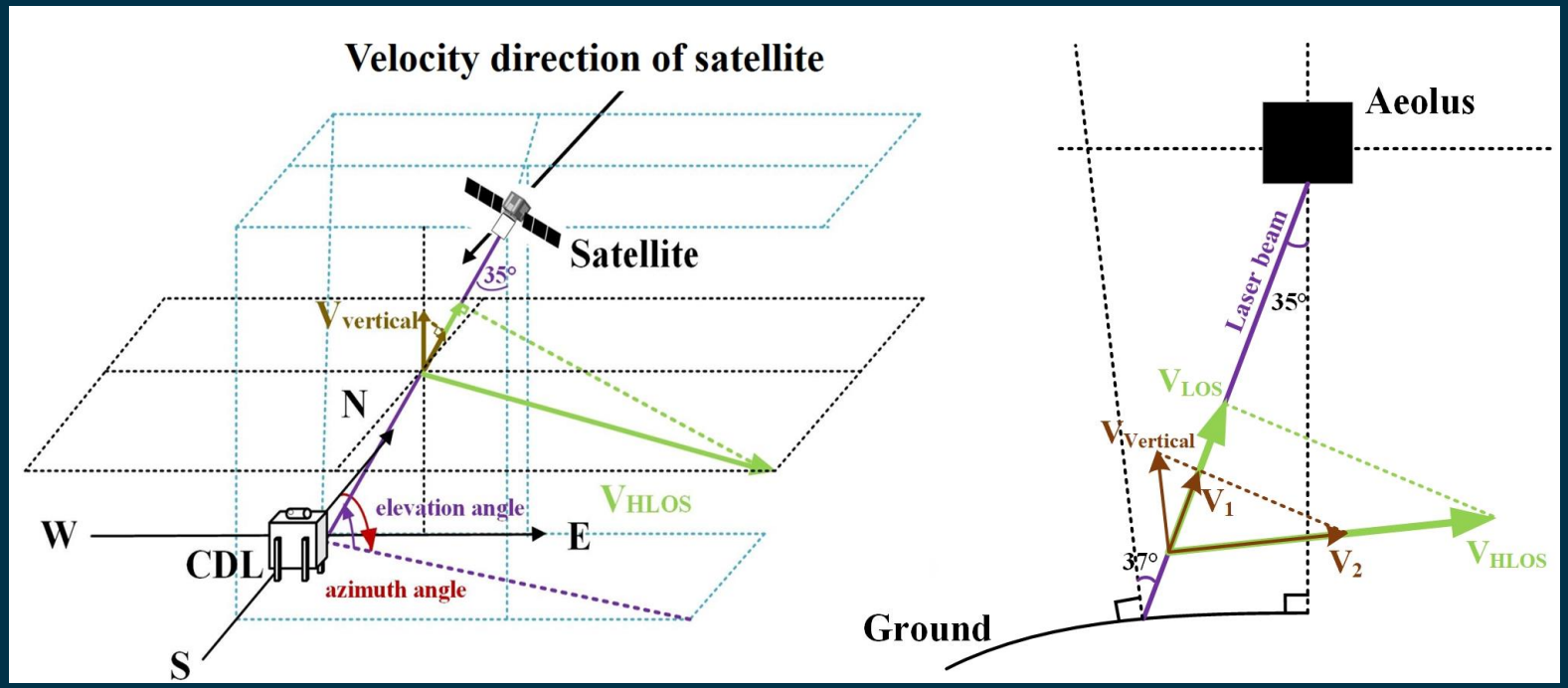
Wind 3D6000/WindMast PBL can act as **reference instrument**.

Inter-comparison strategy and quality control





Influence of vertical velocity on V_{HLOS}



CDL-HLOS→Aeolus-HLOS:

$$HLOS_{Aeolus} = HLOS_{CDL} + V_{vertical} \cdot \cot 37°$$

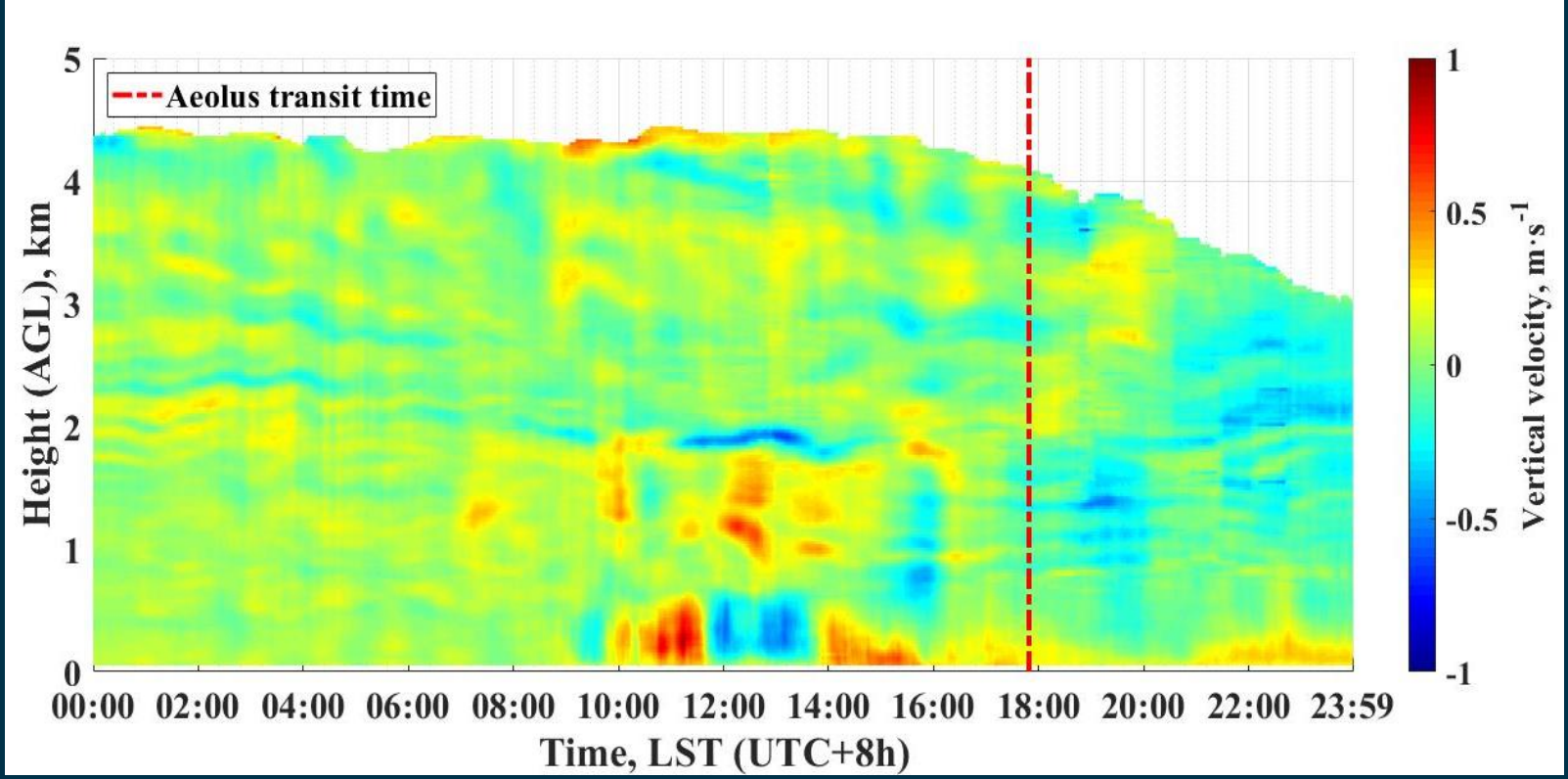
The LOS component of vertical velocity is V_1 = Vvertical · cos37°.

Result from the definition of Aeolus HLOS wind (V_{HLOS} = VLOS/sin37°), the influence of V_1 on V_{HLOS} is V_2 = V_1/sin37°.

Consequently, **the influence of $V_{vertical}$ on V_{HLOS} is V_2 = Vvertical · cos37°/sin37°, i.e. V_2 = Vvertical · cot37°.**

- The vertical velocity correction of CDL-HLOS is only used in the profiles analysis for the method discussion and the corrected CDL HLOS results are not used in the statistical comparison.

Influence of vertical velocity on V_{HLOS}



Vertical wind measurement case by CDL with a moving average of 30 minutes

typical vertical velocity:

0 m/s to ±0.40 m/s

HLOS retrieved difference:

up to ±0.53 m/s

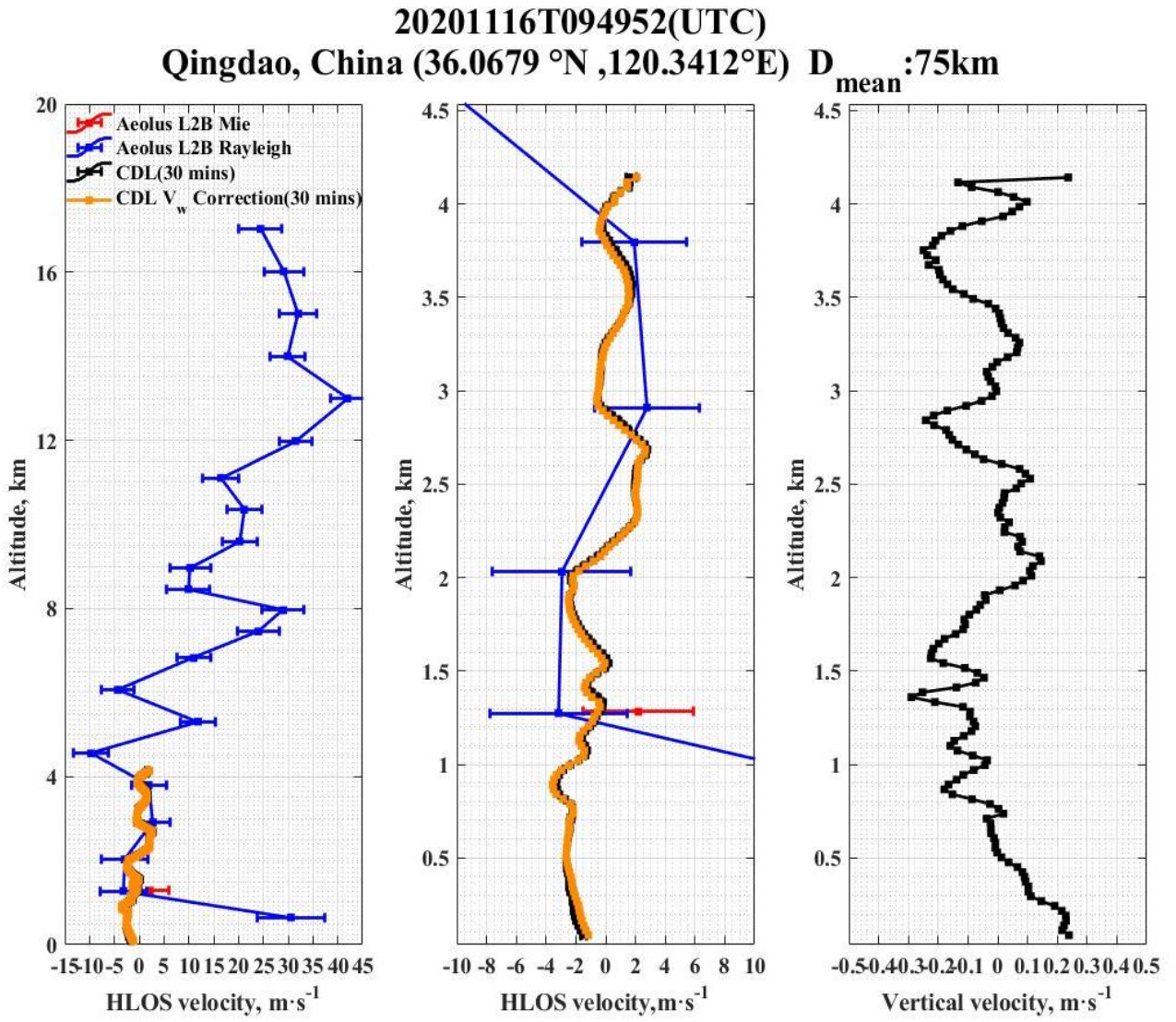
Maximum/minimum vertical velocity:

around 1 m/s/ -1 m/s

HLOS retrieved difference:

±1.33 m/s

Measurement cases over China



Baseline 11

Aeolus L2B Rayleigh-clear HLOS profile:

- In the atmospheric boundary layer and the lower troposphere are almost trustable
- The lowest height bin of Aeolus Rayleigh-clear HLOS profile has a large bias

Aeolus L2B Mie-cloudy HLOS profile:

- In the range of Aeolus estimated error

30-minute averaged vertical velocity profile:

- vertical velocity: mainly in the range of ±0.30 m/s
- HLOS retrieved difference: around ±0.40 m/s

Measurement cases over China

Baseline 07

(after M1 bias correction)

On 21 Jan. 2020

Baseline 08

(after M1 bias correction)

On 11 Apr. 2020

Baseline 10

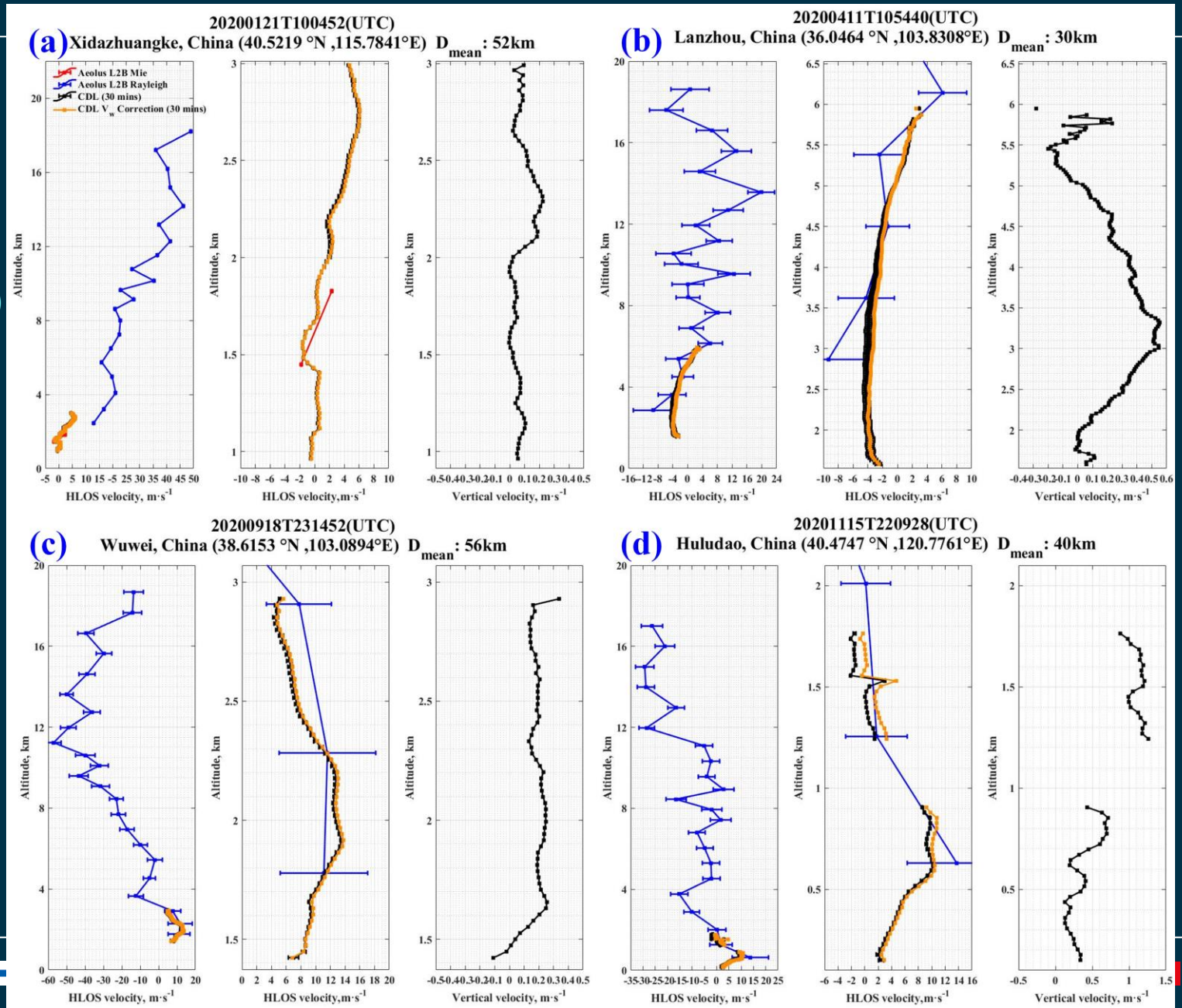
(after M1 bias correction)

On 18 Sep. 2020

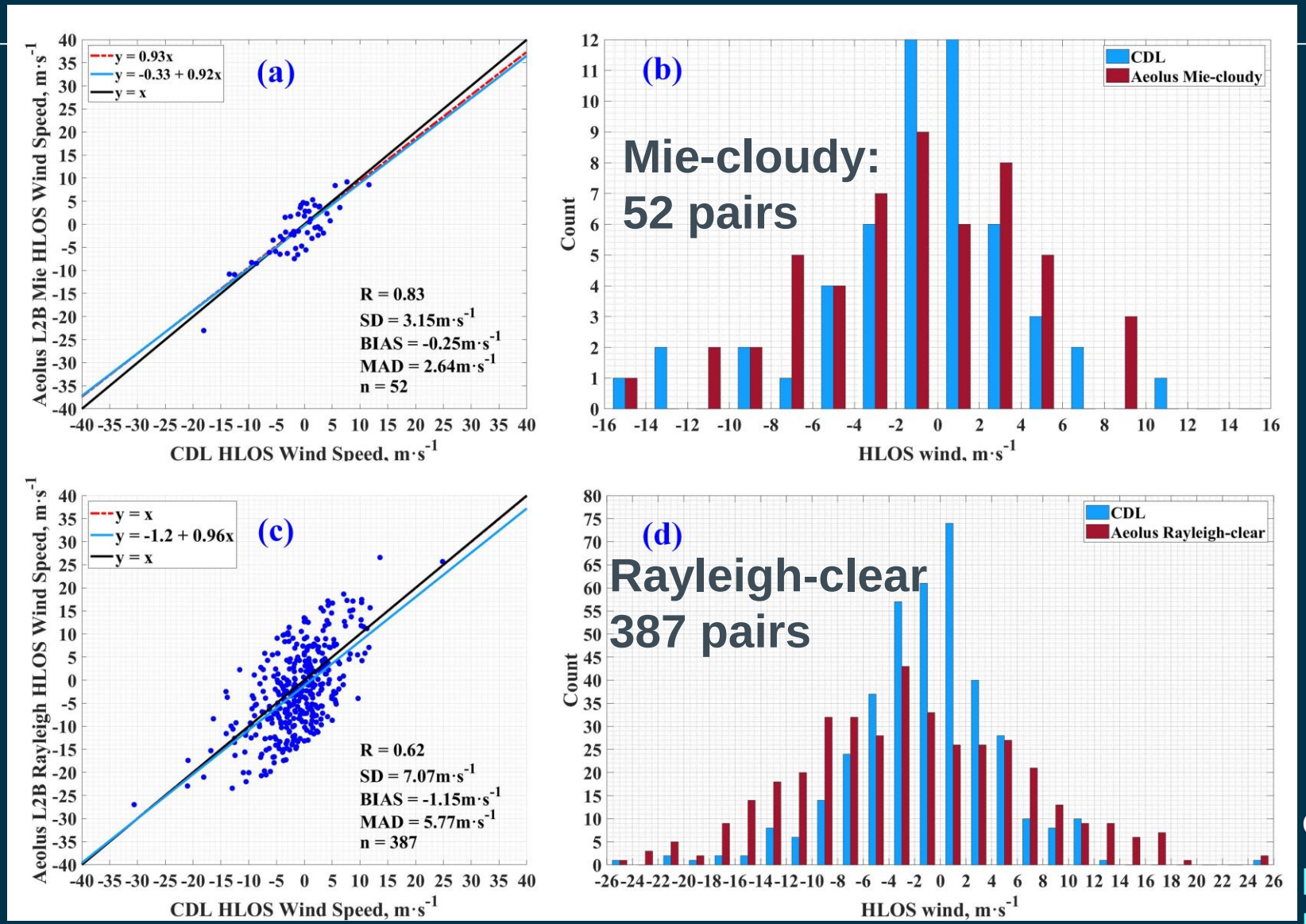
Baseline 11

(after M1 bias correction)

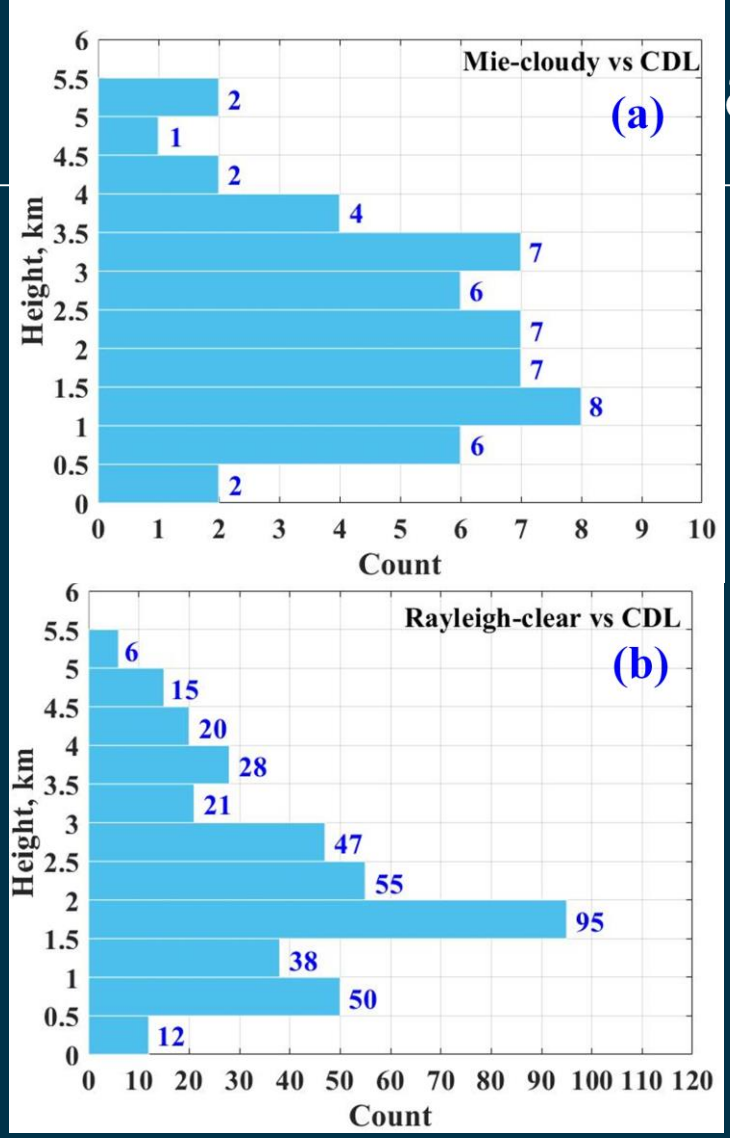
On 15 Nov. 2020



Statistical comparison



Aeolus L2B Rayleigh-clear HLOS & Mie-cloudy HLOS vs CDL HLOS



Counts of data pairs at different height ranges

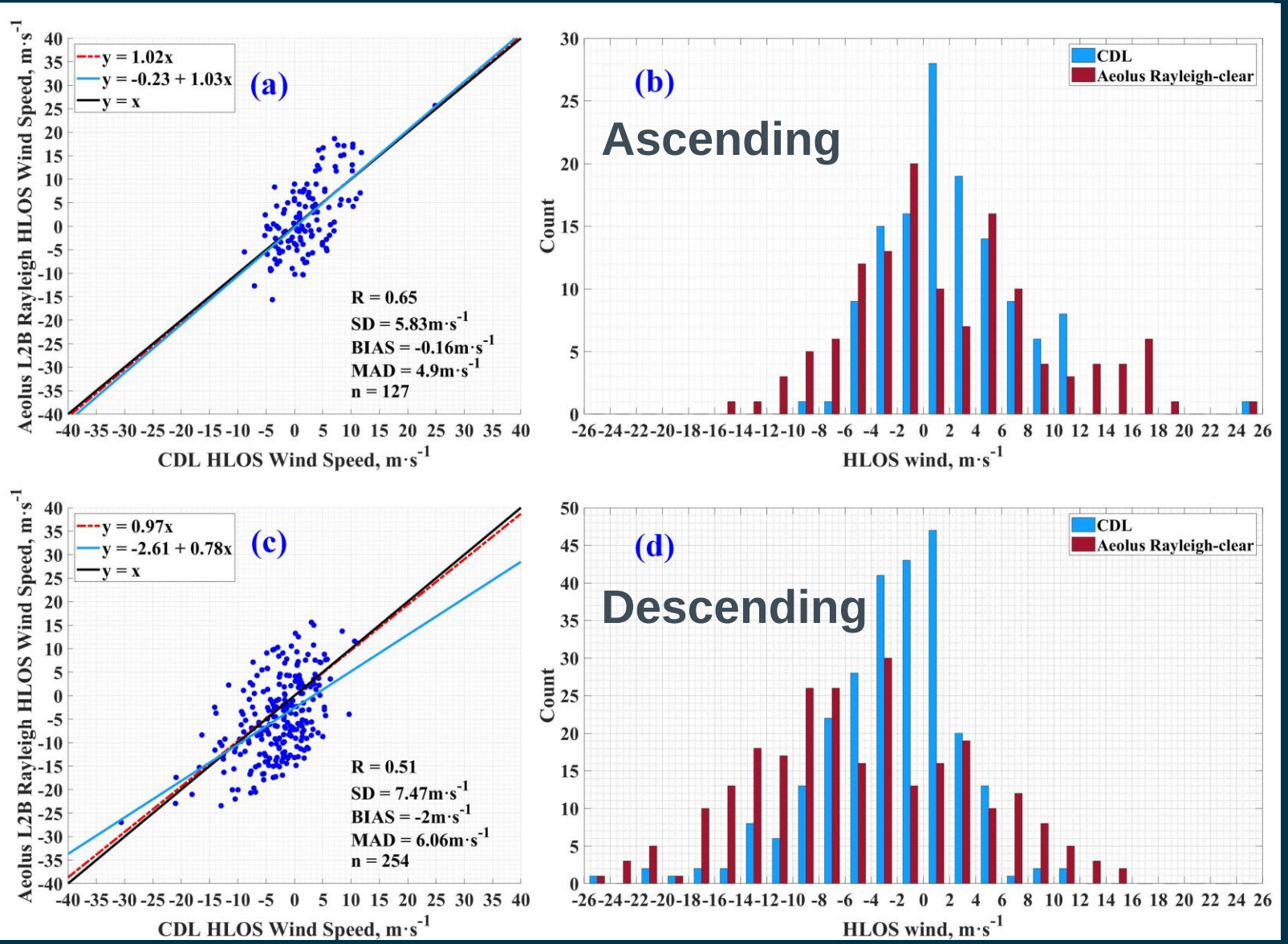
Mainly in the atmospheric boundary layer and the lower troposphere

Statistical comparison

☐ Rayleigh-ascending/descending

Ascending/Descending	Ascending	Descending
N points	127	254
Correlation	**0.65**	**0.51**
SD (m/s)	**5.83**	**7.47**
Scaled MAD (m/s)	**4.9**	**6.06**
BIAS (m/s)	**-0.16**	**-2**
“y=ax” Slope	1.02	0.97
“y=ax+b” Slope	1.03	0.78
“y=ax+b” Intercept (m/s)	-0.23	-2.61

The standard deviation, the scaled MAD and the bias on ascending tracks are lower than that on descending tracks



Statistical comparison

☐ Rayleigh-different Baselines

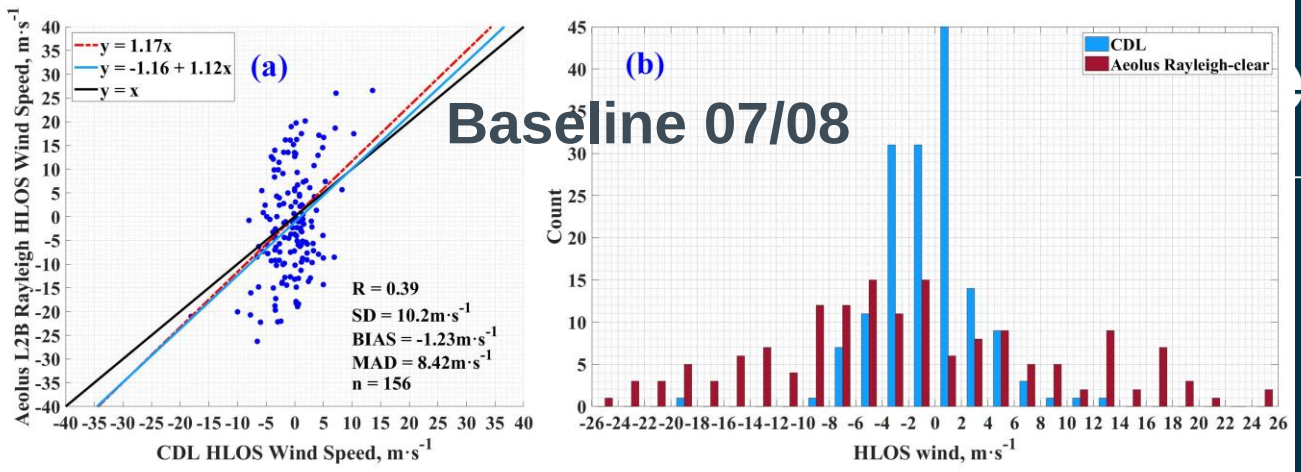
Baselines	07 and 08	09 and 10	11
N points	156	106	100
Correlation	**0.39**	**0.75**	**0.86**
SD (m/s)	**10.2**	**4.66**	**4.76**
Scaled MAD (m/s)	**8.42**	**3.84**	**3.91**
BIAS (m/s)	**-1.23**	**-0.98**	**-0.13**
“y=ax” Slope	1.17	0.99	1.01
“y=ax+b” Slope	1.12	0.97	1
“y=ax+b” Intercept ((m/s)	-1.16	-1.01	-0.12

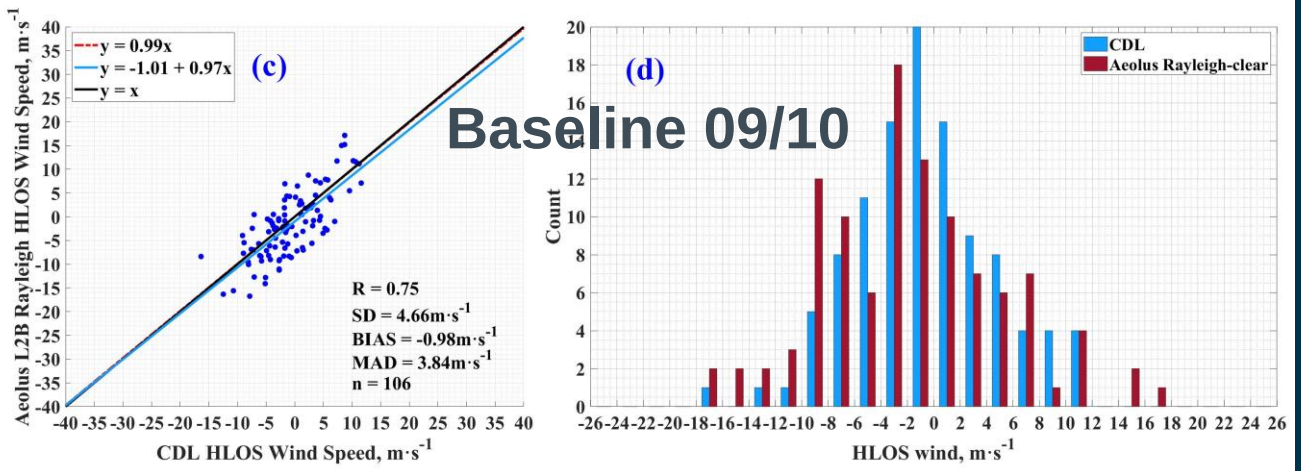
Baseline 07/08: marked misfits

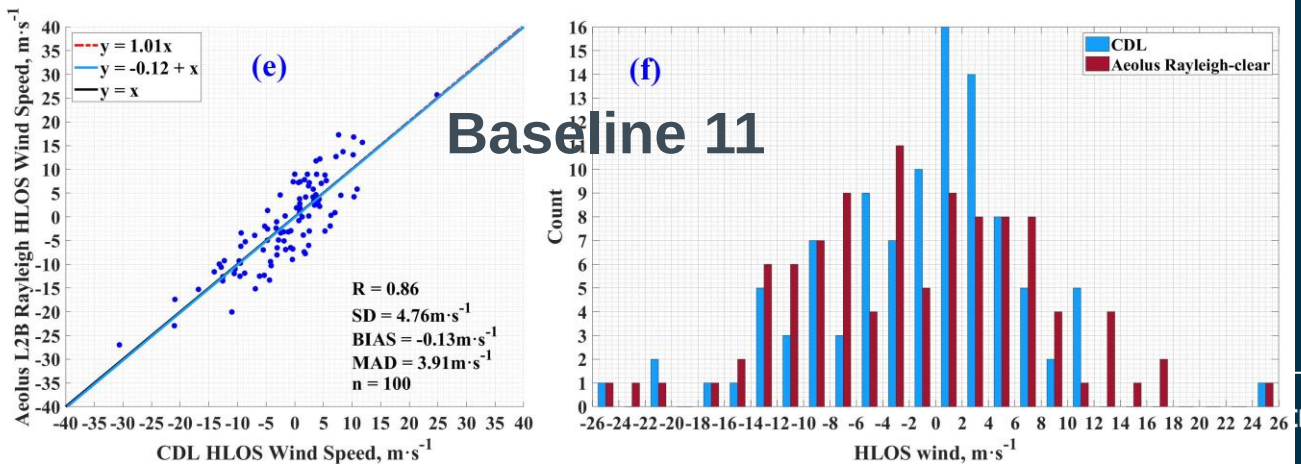
After M1 bias correction:

Baseline 09/10: better correlation, lower SD, scaled MAD than Baseline 07/08

Baseline 11: better correlation, lower bias than Baseline 09/10







Summary

- 52 measurements for Mie-cloudy and 387 Rayleigh-clear cases compared with ground based CDL network (17 CDLs) over China from January to December 2020.
- Both Rayleigh-clear and Mie-cloudy L2B HLOS winds are almost trustable in the atmospheric boundary layer and the lower troposphere, especially after the employment of the processor Baseline 09.

  Mie-cloudy winds: correlation: 0.83； Random error: 3.15m/s, the scaled MAD: 3.15 m/s; bias: -0.25 m/s

  Rayleigh-clear winds: correlation: 0.62； Random error: 7.07 m/s, the scaled MAD: 5.77 m/s; bias: -1.15 m/s

  Ascending: correlation: **0.65**； Random error**: 5.83** m/s, the scaled MAD: **4.9** m/s; bias**: -0.16** m/s

  Descending: correlation: **0.51**； Random error: **7.47** m/s, the scaled MAD: **6.06** m/s; bias: **-2** m/s
- The vertical velocity correction is necessary in the wind retrieval and the validation process for case study.

Special Issue: Aeolus data and their application (AMT/ACP/WCD inter-journal SI)
Title: Inter-comparison of wind measurements in the atmospheric boundary layer with Aeolus and a ground-based coherent Doppler lidar network over China
Author(s): Songhua Wu, Kangwen Sun, Guangyao Dai,et al. MS No.: amt-2021-260


Thanks for your attention