Improvement of Long Range Doppler LIDARs of Mitsubishi Electric Corporation (MELCO)

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Introduction

Wind measurement is considered as one of the most important issues for the prediction and elucidation of meteorological phenomena. As the formal instrument for wind measurement, ground-based anemometer, radiosonde, Doppler radar and Wind Profiler are utilized so far. However, it is quite difficult to scan the three dimensional (3D) wind field including zenith, and only Doppler radar can be utilized to measure 3D wind speed and direction in the case of rainfall.

In recent years, Doppler LIDARs have been developed and it can scan 3-D wind field even in the case of fine weather and is proceeded to be utilized in a variety of fields.

Therefore, it is possible to implement all-weather wind measurement with the set of Doppler LIDAR and Doppler radar and this set is much effective to monitor the safety of air at the airport, launch complex and other fields.

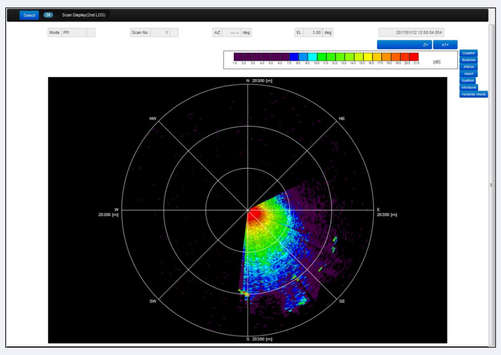
Coherent Doppler LIDAR

Fig.1 External view of DIABREZZA^{TM} A Series

■ DIABREZZA^{TM} A Series

Since 2013, MELCO developed the the 2nd generation model named '**DIABREZZA^{TM} A Series**' for microburst / wind shear detection uses at airports.

■ Signal to Noise Ratio (SNR)



■ Line-of-Sight Velocity (LOS)

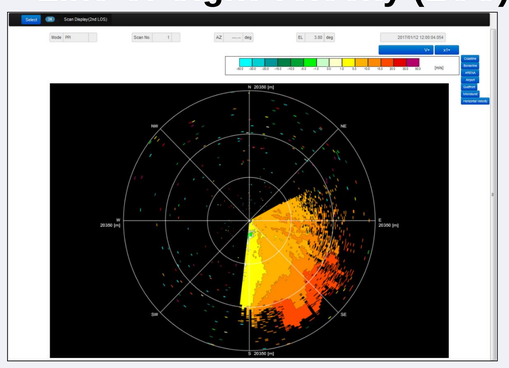


Fig. 2 Screen examples of DIABREZZA^{TM} product data

- ✓ DIABREZZA^{TM} A Series has now the most powerful transmitter in the worlds, which is called '**Planar waveguide amplifier**'.
- ✓ In 2016, MELCO improved this LIDAR system to add a new function for zenith observation to obtain vertical wind profiles up to 15km or more of height.

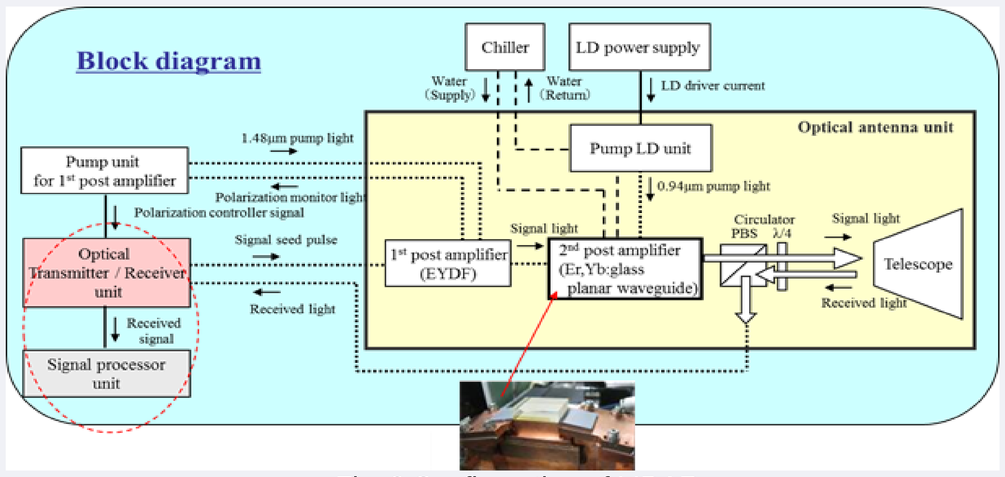


Fig. 3 Configuration of LIDAR

Item	DIABREZZA^{TM}
Pulse Energy	3.0 mJ
Wavelength	1550 nm
Repetition	1 kHz
Pulse Width	400 ns
Ave. Power	3.0 W
Typ. Range	**20 km**
Max. Range	**> 34 km**
Telescope Dia.	10.0 cm

Table 1 Specification of LIDAR

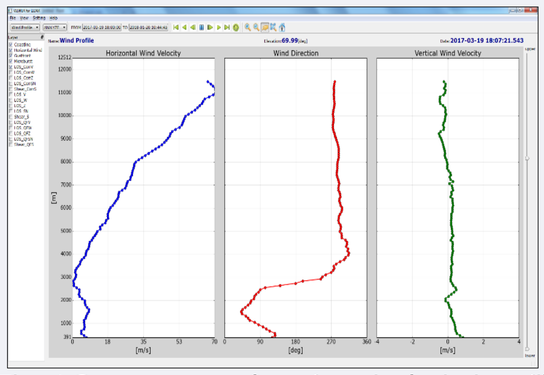


Fig. 4 Screen examples of vertical wind profile

LIDAR observation system linking with Radar

■ Thunderstorm Forecasting System

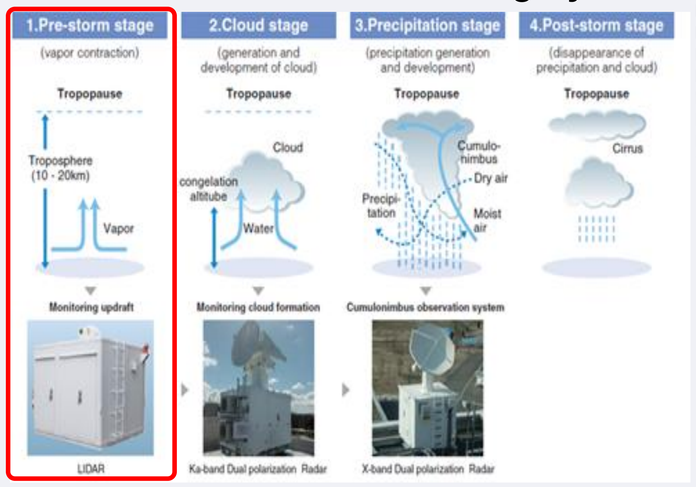


Fig. 5 Thunderstorm forecasting system

- ✓ The indication of torrential rain can be detected 20 min. before by Ka-band.
- ✓ For detecting that indication faster (e.g. 1 hour before), it is considered as most effective to observe the ascending air current including water vapor by LIDAR.

■ Wind shear detection system

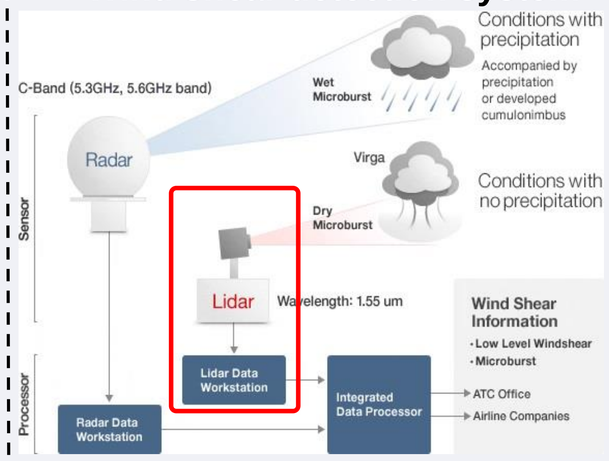


Fig. 6 Wind shear detection system

- ✓ Radars can detect turbulences in the rain and LIDAR can do that in fine weather.
- ✓ By combining TDWR* and CDL, an all-weather turbulence observation system is obtained.

* Terminal Doppler Weather Radar

Results for Inter-comparison with Radiosonde

■ Introduction

- ✓ KARI** and MELCO utilize LIDARs including a new function for zenith observation.
- ✓ Wind Profiler had the experience to observe wind vertical profile with an altitude of 9 ~10km.
- ✓ We have performed the inter-comparison test up to 10 km with Radiosonde for the reliability verification of LIDAR.

** Korea Aerospace Research Institute

■ Test procedure

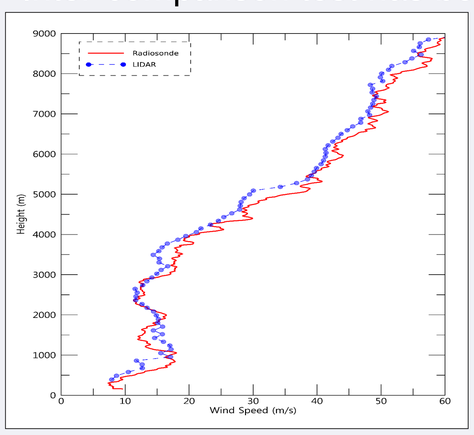
- ✓ Radiosonde goes up from the ground to an altitude of 10km with Weather balloon for 30 min. and outputs 1 min. averaged data.
- ✓ LIDAR data is outputted every 2 min.
- ✓ Refer to 'Altitude' and 'Timestamp' of Radiosonde, the nearest LIDAR data is chose to compare every 2 min.

Item	DIABREZZA^{TM}
Range bin	200bins
Range Resolution	150m
Observation Range	400m ~ 30km

Table 2 LIDAR observation parameter

■ Result

Inter-comparison test has been performed for 25 times (01~03.2017).



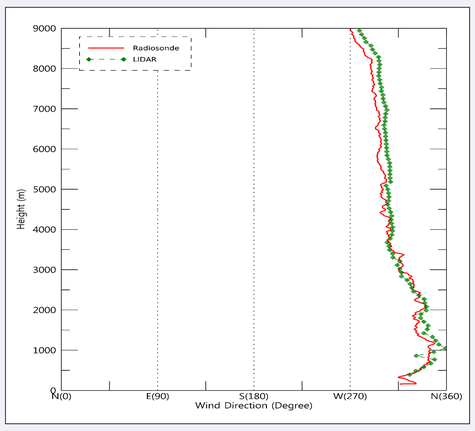


Fig.7. Correlation plots of WS (Upper) and WD (Lower), on Feb.2

No.	Date	Max. comparison hgt.	R (WS)	R (WD)
1	Jan.10 (09:40~)	7.81 km	0.99	0.97
~	~	~	~	~
14	Feb.7 (09:26~)	10.45 km	0.99	0.79
~	~	~	~	~
17	Mar.2 (10:24~)	6.88 km	0.83	0.94
~	~	~	~	~
25	Mar.15 (18:06~)	9.60 km	0.99	0.95
	Average		**0.98**	**0.87**

Table 3 LIDAR observation parameter

- ✓ The Correlation Coefficient of wind speed & wind direction between DIABREZZA^{TM} and Radiosonde was **0.98** and **0.87**, respectively.
- ✓ DIABREZZA^{TM} has an excellent observation performance up to 10km.
- ✓ MELCO will proceed to tune VAD algorithm for improving the result of No.14, 17.

[Note] There are some cases that the maximum comparison height is reached to only 8km or less, due to the cloud limitation and low density of aerosol.

Conclusions

KARI and MELCO has proved that DIABREZZA^{TM} is a very useful device for upper air observation. KARI is expected to develop new applications for DIABREZZA^{TM}.