Measuring wind conditions and wind hazards with new generation LIDARs for improving air traffic management

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Abstract

The current and continuous growth of air traffic associated with the necessity to improve safety implies the development of new ATM regulations and new advanced integrated systems that must be fed by accurate and frequent weather conditions especially for improving the meteorological awareness and thus reducing the weather impact on ATM operations. The measurements of winds and wind hazards like wind shears with coherent Doppler LIDARs allow to provide high resolution observations in order to warn airport meteorologists and air traffic controllers of any danger and to improve weather forecasts with assimilation. This poster present the main chacrateristics and added values of WINDCUBE Scanning LIDARs as operational met sensor for airports as well as its evaluation in SESAR weather project 15.4.9c for building a Ground Weather Monitoring System (GWMS) combining all sources of MET data relevant for the airport.

The WINDCUBE Scanning LIDAR performances

The WINDCUBE Scanning LIDARs are based on the Fiber Laser technology developed by ONERA and industrialized by LEOSPHERE for 10 years. **More than 550 pulsed coherent Doppler LIDARs have been industrialized worldwide** for various applications, from wind energy to aviation weather and meteorology. This technology allows reliable and low-cost operations thanks to the use of optical fibers for guiding and amplifying the light. The accuracy of wind measurements remains stable in time and in distance thanks to the heterodyne detection and laser pulses while being compliant with eye safety standards (IEC/EN 60825-1).

Man Specifications for WINDCUBE400S-AT	
Range of measurement	Up to 13km, typically 8 to 9km din nominal atmospheric conditions for LIDARs (visibility above 10km, no rain)
Scanning Patterns	Single Line of Sight, DBS, PPI and RHI
Accumulation time	0.5s to 10s (min 50ms for specific applications)
Scanning Speed	From 0.5°/s to 12°/s while measuring. Up to 30°/s else
Resolution	From 75 to 200m
Power supply	100-240V AC/ 50-60 Hz
Electrical consumption	Max 1.6kW with max coolers or heaters
Dimensions (LxWxH) and weight	1008mm x 814mm x 1365mm and 232 kg

Table 1: Main technical characteristics of the WINDCUBE400S

Figure 1: WINDCUBE400S installed at Braunscwheig airport

The WINDCUBE scanning LIDARs provide as output the radial wind speeds, its dispersion and the LIDAR signal. For aviation weather and meteorological applications, PPI scanning patterns at low elevation (3° typical) are used to monitor the wind condition around the airport.

Fig.2 represents the radial wind speeds provided by one 360° PPI scan at 3° of elevation upto 13km. The accuracy of radial wind speeds has been assessed on a reference test site at Denmark Technical Univeristy (DTU) against a calibrated met mast. The accuracy obtained on 10 minutes averaged was 0.36m/s.

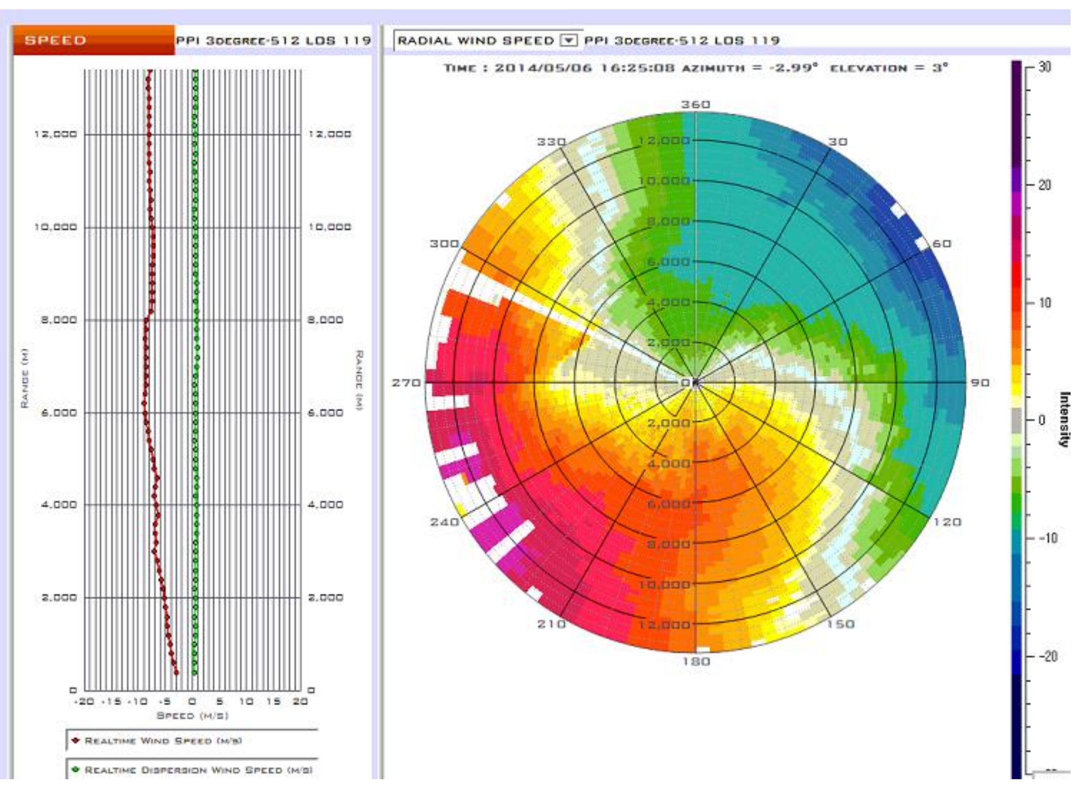

Figure 2: Example of radial wind speeds measured in PPI

EVALUATION IN SESAR 15.4.9c WORKPACKAGE

In order to evaluate the benefits of new sensors like the WINDCUBE Scanning LIDARs for aviation weather, a WINDCUBE400S has been deployed with a METEOR 50DX X-Band RADAR from SELEX ES on the European evaluation airport of Braunschweig in Germany in the framework of the SESAR workpackage 15.4.9c led by SELEX ES related to meteorology.

In addition to the permanent sensors at Braunschweig airport, a METEOR 50DX X-Band Scanning RADAR and a WINDCUBE400S Scanning LIDAR were installed respectively on January 26th and February 25th, 2015, separated from 50m. The LIDAR was configured in order to perform a sequence of 3 PPIs at 3, 6 and 20° repeated every 4min, DBS vertical profiles every 2min, RHI along the runways repeated every 5min. In addition two resolutions were used 75m and 200m. The finest resolution was chosen to have a better monitoring of the vertical structure within the boundary layer.

Many different weather conditions occurred during the trial from snow, drizzle, fog, rain and clear sky as well as two spring storms with high gust fronts. The WINDCUBE400S has been operated constinuously during 2 months with an uptime ratio of 96%. Following recent recommendations from the ISO standardization group on Doppler LIDARs, an assessment of the range performances in clear air (visibllity > 10km and no rain) has been performed. The WINDCUBE400S **has been measuring up to 7.3km and 10km respectively 80% and 50% of the time**.

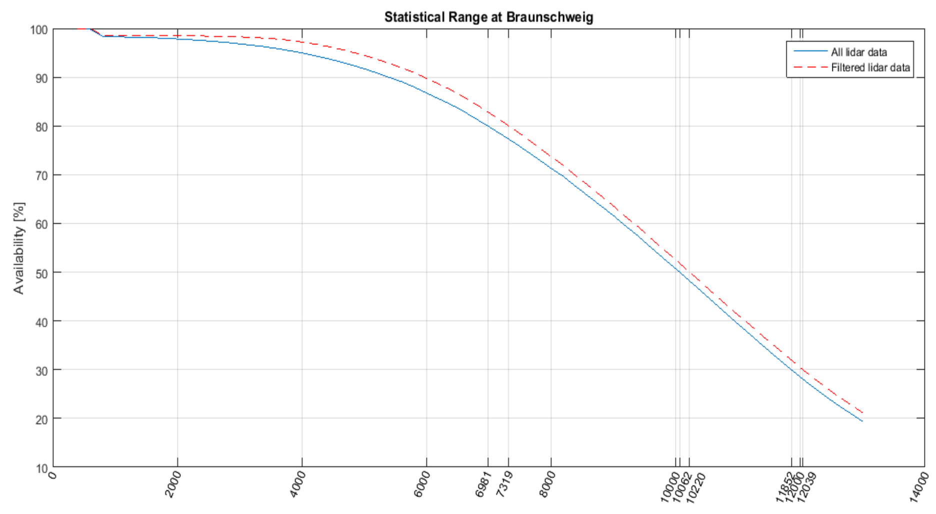

Figure 3: Statistical range of the WINDCUBE400S LIDAR

A analysis of the weather impact on range has also been realized. It shows that the LIDAR range is reduced under moderate and heavy rains. This confirms that the LIDAR must be combined with an X-Band RADAR for building an all weather observation system.

COUPLING WINDCUBE LIDAR WITH X-BAND RADAR

The data collected by the RADAR and the LIDAR have been integrated and post-processed by the RAINBOW5 software developed by SELEX ES. When comparing measurements performed by LIDAR and RADAR, we confirm that under rainy conditions, the RADAR covered the airport area, whereas under clear air conditions the LIDAR did. Mixed conditions with showers and light rains show that RADAR and LIDAR can monitor different areas.

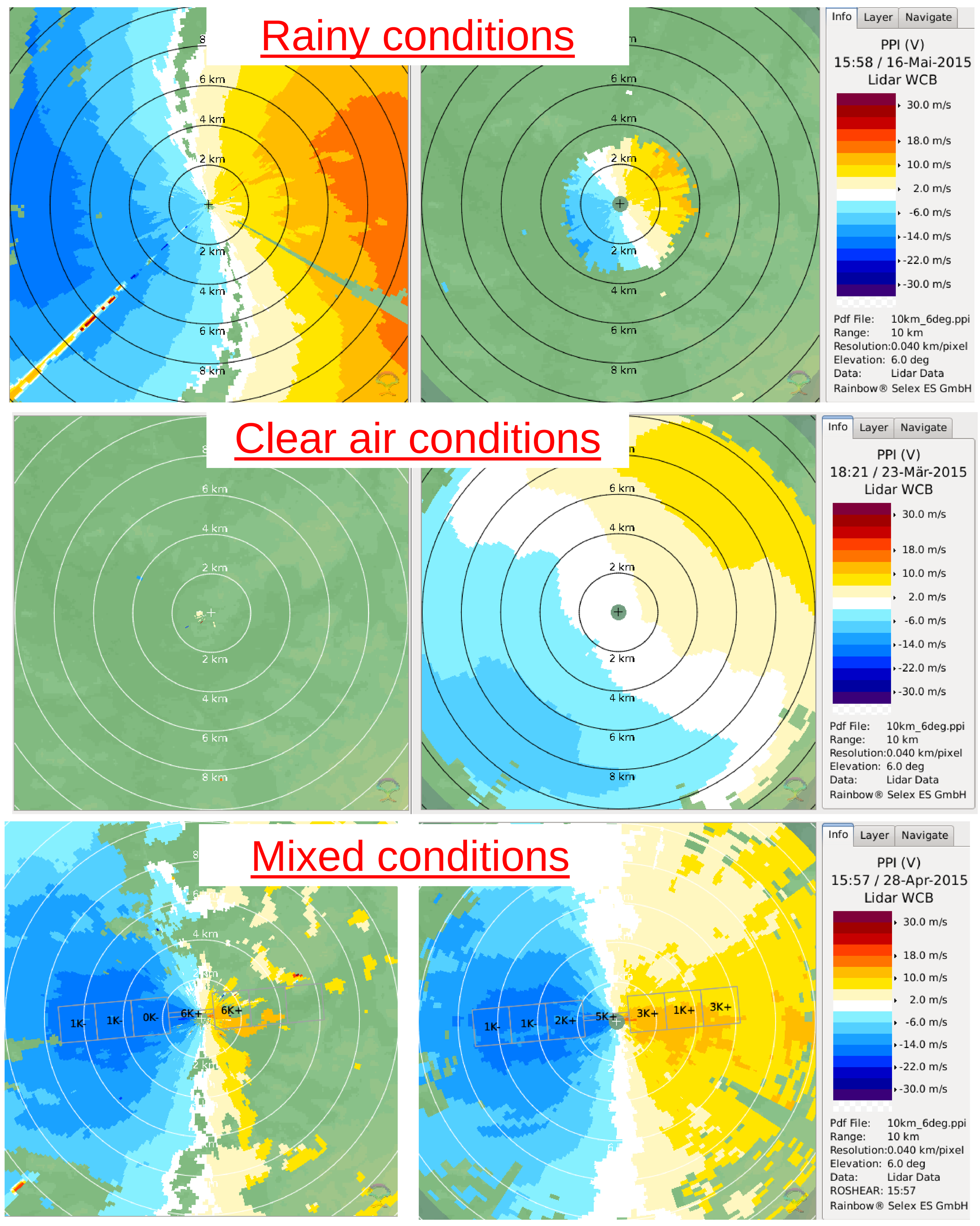

Figure 4: RADAR and LIDAR PPI scans for rain (top), clear air (middle) and mixed (bottom)

In addition, different advanced products have been applied to RADAR and LIDAR radial data like the wind shear alert algoritm (ROSHEAR) and the gust front detection. The alerts provided by RADAR and LIDAR can be combined to provide integrated products for meteorologists and air traffic controllers.

Conclusion

The WINDCUBE400S Scanning LIDAR is currently under evaluation for SESAR workpackage 15.4.9c related to weather. Preliminary results show a good agreement between the LIDAR operational and functional performances and SESAR requirements. The benefits of the RADAR + LIDAR coupling for measuring wind and wind shears have been demonstrated. Further analyses are on-going on other added values products. If the use of LIDAR sensors remains limited in aviation weather, strong improvements of the technology as well as on-going standardization activities will support the development for its use in operational applications.

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