Validation of Electromagnetic Wind Radar Simulator Based on LES with Scanning X-band Radar Measurements and Meteorological Data

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Context and Results

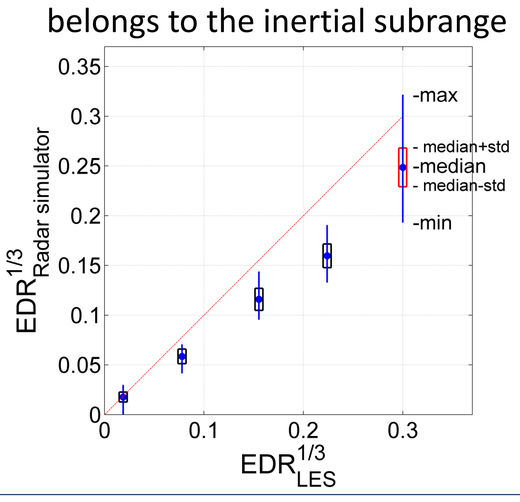
Context:

An electromagnetic radar simulator was developed by UCL in the framework of FP7 UFO project. Results of the simulation were compared with measurements using a scanning X band radar developed by Thales and meteorological data provided by Meteo France.

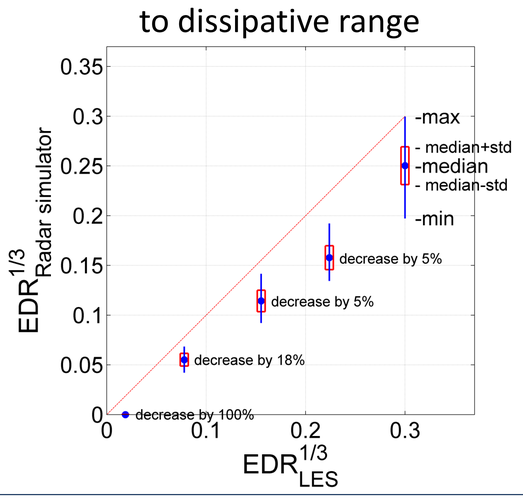
The simulator is developed for radar cross section, wind and energy dissipation rate (EDR) retrieval, in clear air and in the presence of rain. It is based on the refractive index calculated from Large Eddy Simulations (LES) of the turbulent atmosphere in the boundary layer. The refractive index is then used for the calculation of the radar cross section of the turbulences as well as the power received by the radar and the Doppler spectrum. EDR is estimated from the simulated Doppler spectra.

Scatter plot of EDR values retrieved from the simulator against input LES EDR

Assumption that Bragg wavelength belongs to the inertial subrange

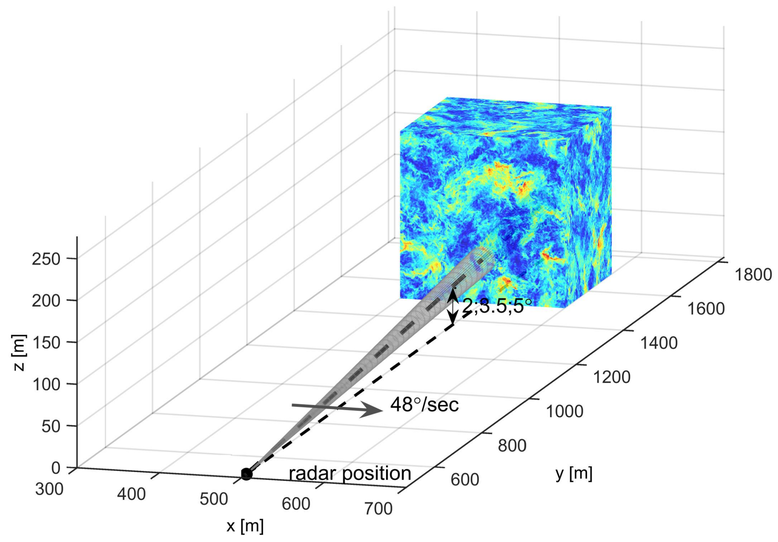


Transition from the inertial subrange to dissipative range



Radar Simulator

Simulator Geometry Configuration



Radar Signatures Simulation

Input: → **Scattering mechanism:** → **Calculation of the radar signatures:** → **Output parameters estimation:**

A set of LES (simulated by iMMC, UCL) with different stratification levels and energy dissipation rates (EDR) (with or without raindrops). LES introduced as a box with values of parameters at equidistant grid nodes.

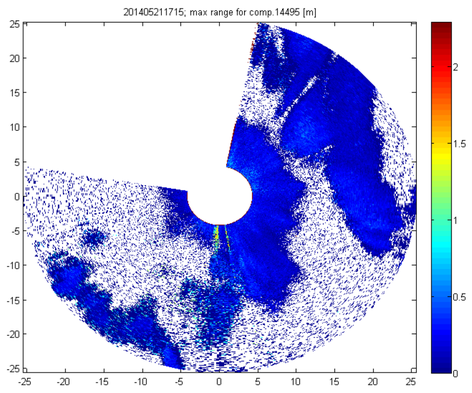
1. **Bragg scattering** on clear air turbulence (inhomogeneities of the refractive index of the air)
2. **Rayleigh/Mie scattering** on the raindrops

1. I/Q of the scattered signal
2. Doppler spectrum of the scattered signal
3. Radar Cross Section (RCS)

1. Energy dissipation rate
2. Wind velocity and direction

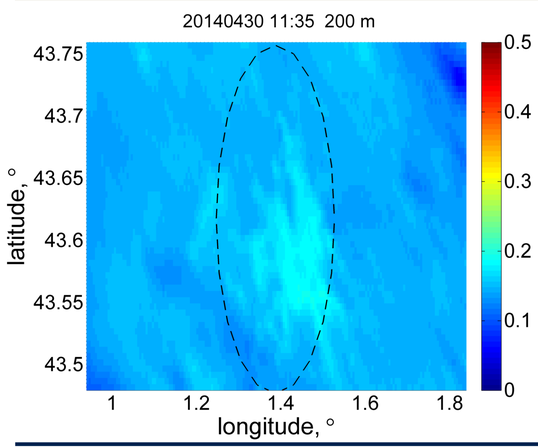
Radar Measurements vs. Meteorologica Data

EDR from X-band Thales Radar Measurements



- In the scanned sector from ~4.5 km to 25 km around Toulouse airport
- 3 elevation angles: 2˚; 3.5˚; 5˚
- 10 days of measurements

EDR from Meteo France Meteorological Data

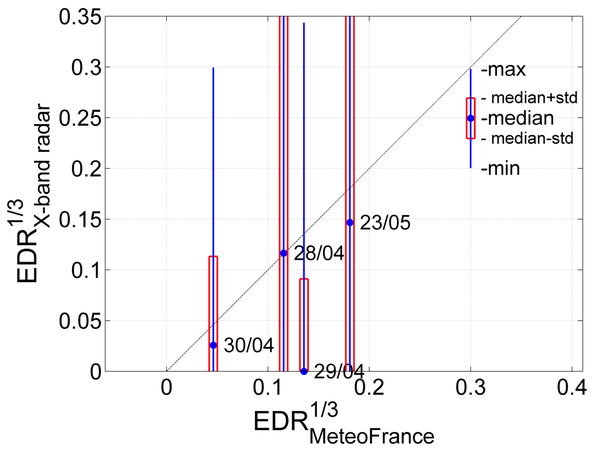


- Latitude from 43.24˚ to 44.04˚
- Longitude from 0.94˚ to 1.84˚
- Step 0.05˚
- Altitudes from 10 m up to 500 m with a step of 10 m
- Pressure, temperature, humidity, turbulence kinetic energy, EDR, u- and v-wind components

Radar Parameters

Power	600 W
Antenna gain	38 dBi
Antenna aperture	1.8˚
Frequency	9.5 GHz
Range resolution	60 m
Pulse repetition frequency	4-5 kHz
Pulses in a burst	512
Antenna scan rate	48˚/s

Scatter plot of EDR from radar measurements against meteorological EDR



- Statistics of EDR obtained on 30 minutes intervals
- Wind shear contribution estimated and removed from the Doppler spectrum width
- 29/04 – low reflectivity

There is no "ground truth value for EDR“

a. Meteorological data is the output of the Weather Prediction Model (HARMONIE-AROME) model based on meteorological observations assimilation
b. Radar measurements is the estimate of the real EDR

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