Refractivity Turbulence in Atmospheric Boundary Layer by Radar and In-situ Measurements at Hectometer Scales

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1. Using French radar network

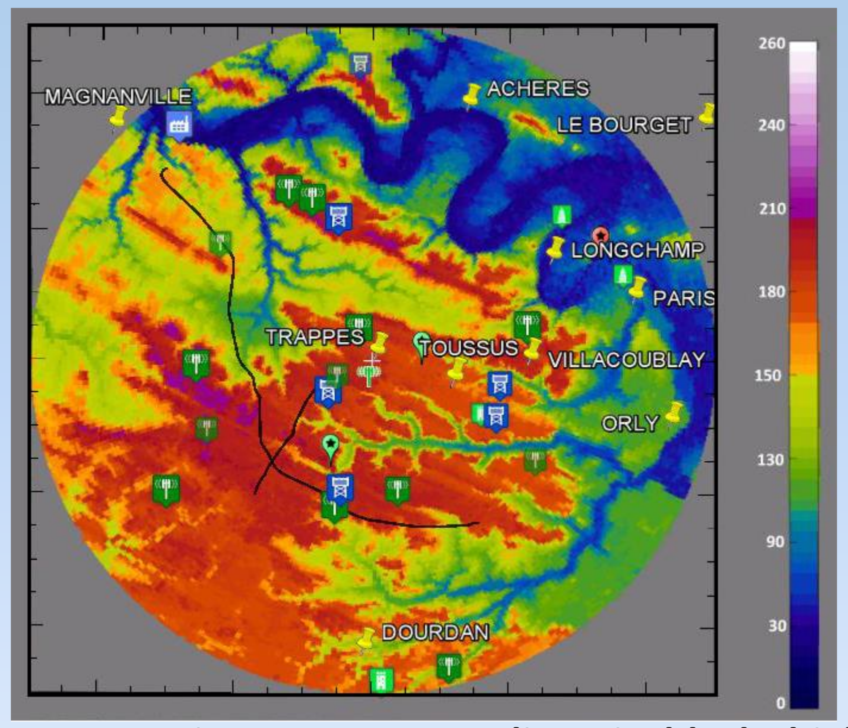
Using signals from ground targets located around, weather radars can measure changes in the refractive index of air. It provides information on atmospheric refractivity (*N*) related to pressure, temperature and humidity (*Bean et Dutton, 1968*):

$$N = (n-1)\times 10^6 = 77{,}6 \times \frac{P}{T} + 3{,}73.10^5 \times \frac{e}{T^2}$$

When refractivity is most sensitive to humidity, the signal has a stronger variability, probably caused by turbulence in the lower layer of the atmosphere.

An analysis based on 1-year dataset from the C-band radar of Trappes and Automatic Weather Stations (AWS) refractivity measurements is used to sample temporal and spatial variability.

1. Target Selection:



A lot of targets are available at the lowest elevation angle. Target must be selected for their suitability for refractivity measurement.

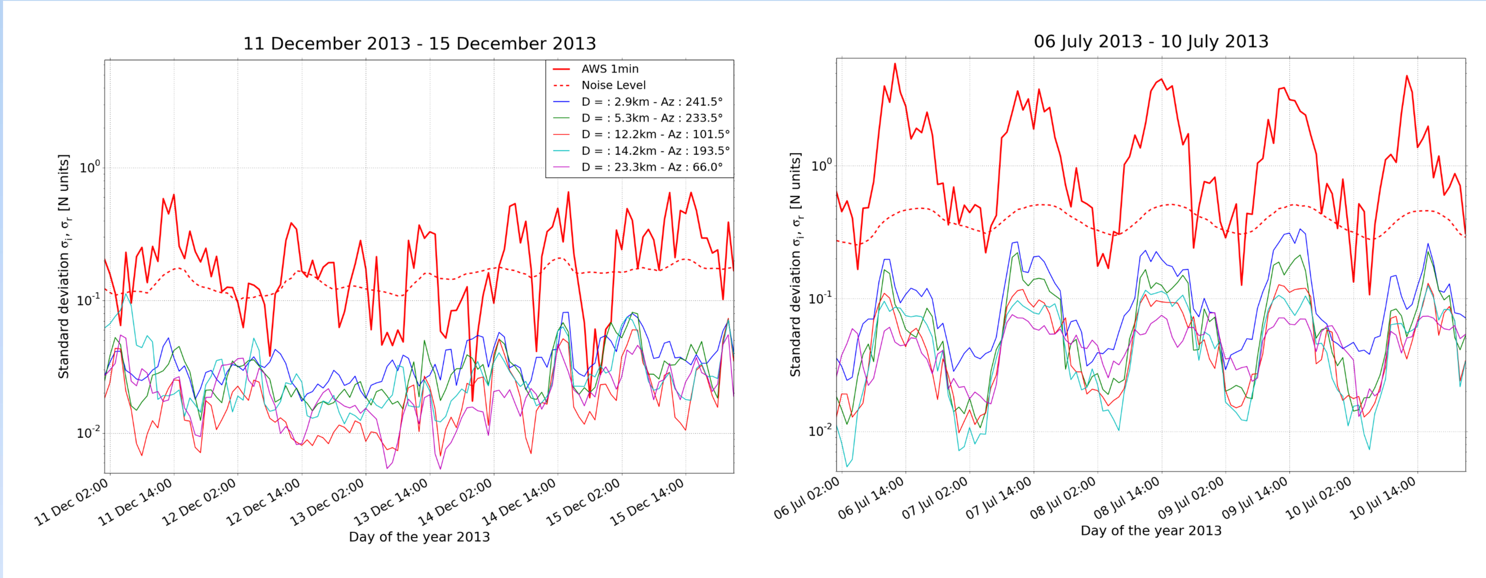
Map of topography around the radar of Trappes.

"Reference targets" are plotted: water tower in blue, antennas in green, power lines in black, high buildings in light green and the Eiffel tower in red. AWS are represented as yellow icons with their names.

2. Comparison between AWS/radar refractivity variability:

To quantify the variability a "Sliding window 2-h standard Deviation of Variation rate of refractivity is used:

$$SDV^2 = \frac{1}{\mathrm{m}}\sum_{h-1\,hour}^{h+1\,hour}\left[\frac{\Delta N}{\Delta t} - E\left(\frac{\Delta N}{\Delta t}\right)\right]^2$$



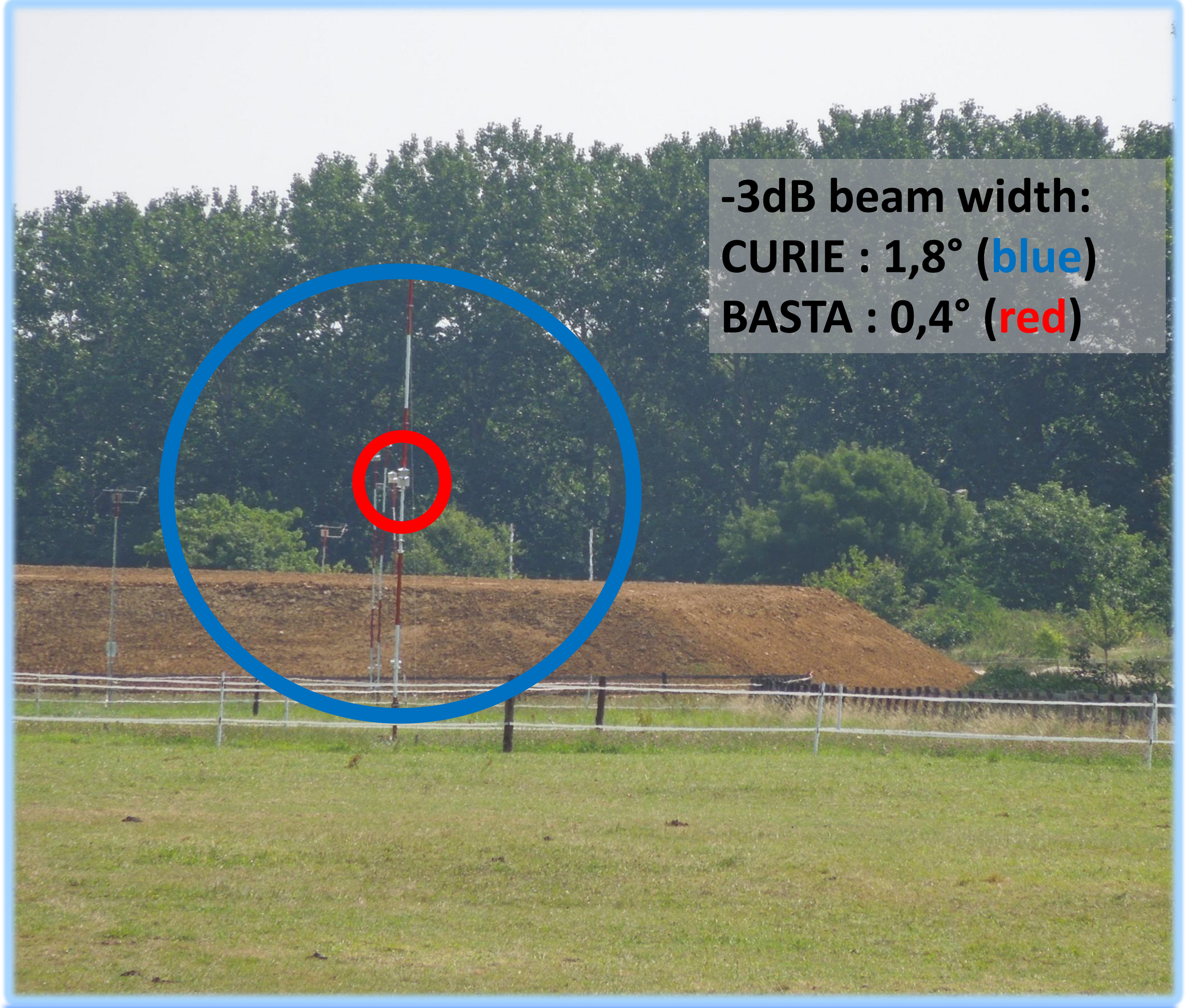
It appears that radar and AWS variabilities are well correlated for all the targets at different ranges. A seasonal effect is also clear.

2. TeMeRAiRE field campaign

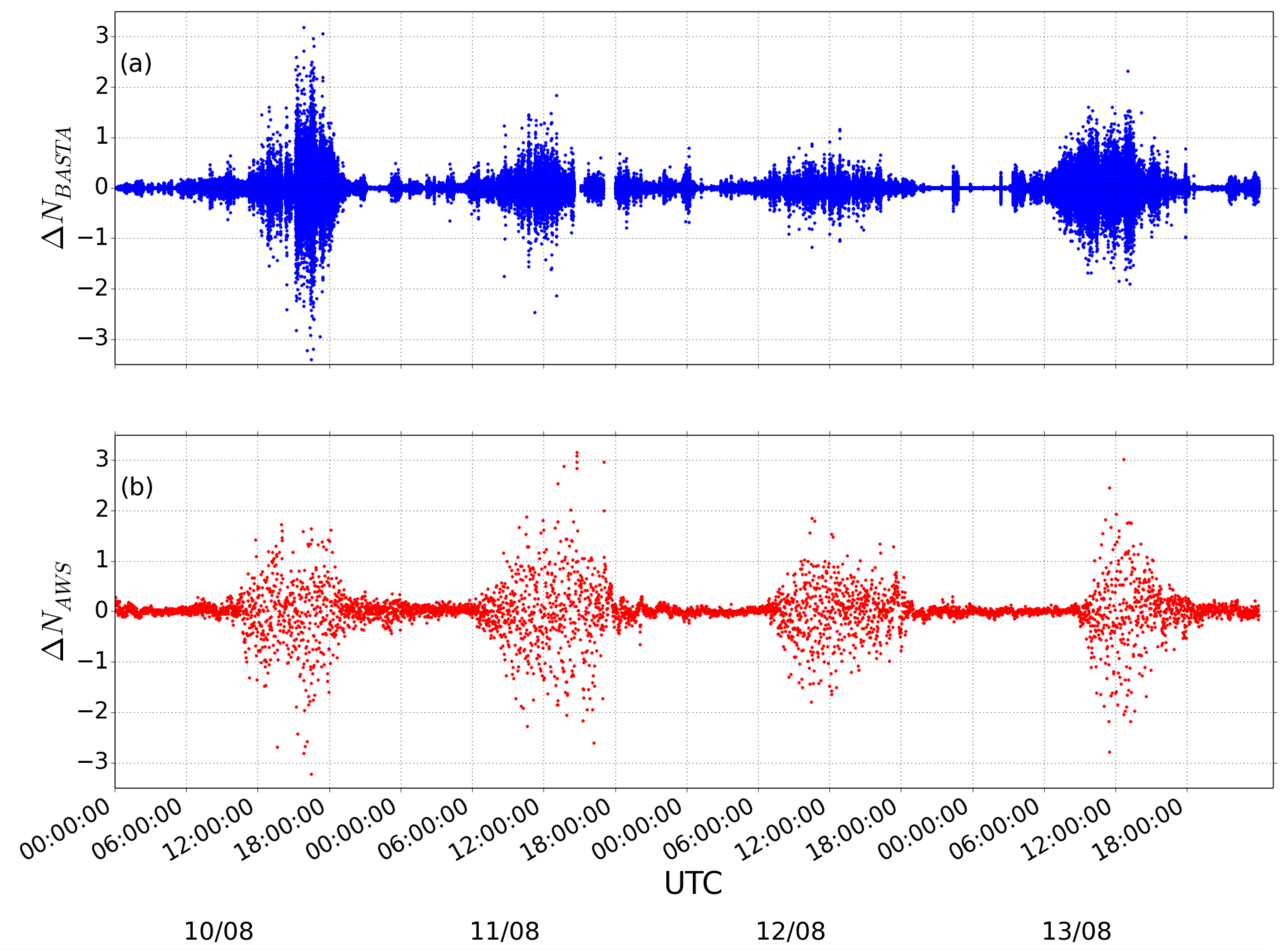
Using the radar network it appears that the measured refractivity variabilities are obviously impacted by turbulence in the boundary layer. To confirm and complete this study, a field campaign was set up in summer 2014 at the SIRTA atmospheric remote sensing site near Paris. The objective of this project was to analyze whether the refractivity variability measured with radars (X and W band) could lead to information at hectometer scales on turbulent behavior of the atmosphere. We want to estimate and compare the coherence between:

1. **In-situ refractivity measured near the targets**
2. **Space-averaged refractivity between radar and targets at 300, 500, 550 and 650 meters.**
3. **Space-averaged refractivity between two targets spaced by 50, 100, 200, 250 and 350 meters**

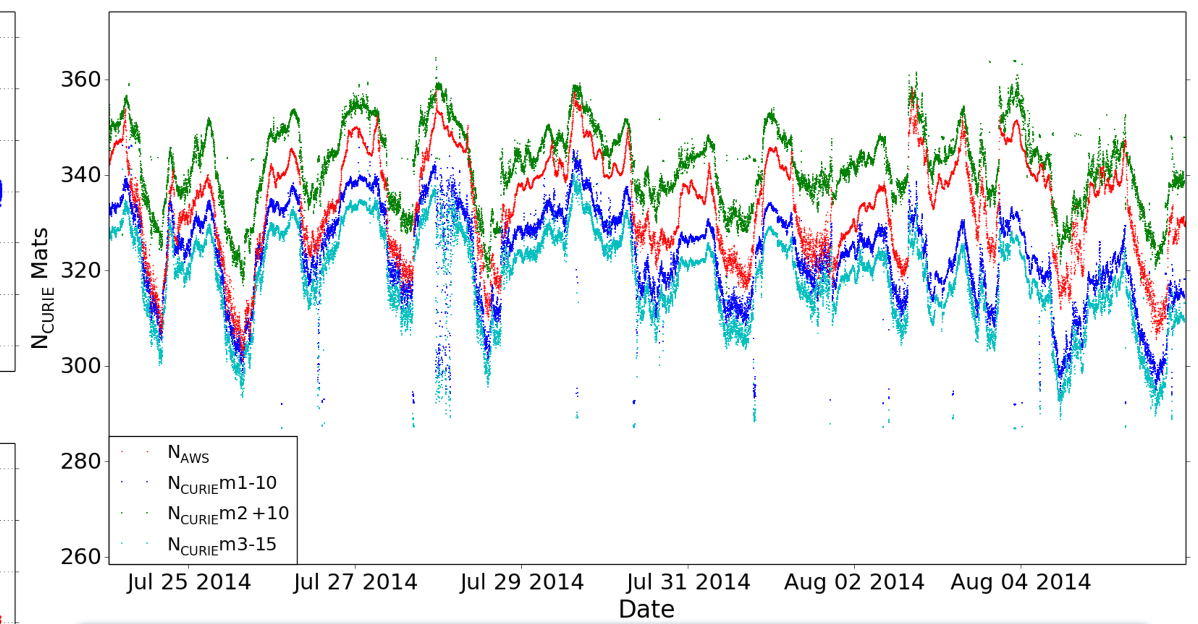
Two radars were pointing horizontally toward four calibrated targets and measured the refractivity variations during two months with sampling rates of 0.25 s and 1.5 ms. Several instruments allowed comparison between radar refractivity measured by CURIE and BASTA and in-situ measurements.



4 calibrated targets and in-situ measurements masts from SIRTA (27/07/2014)



Refractivity variations from radar BASTA using phase signal from target n°4 from 10th to 13th August In-situ 1 refractivity variations for the same period.
We can observe a quite good correlation between in-situ and radar even if some differences exist during the afternoon



Refractivity variations from 24th July to 7th August 2014 with radar CURIE. In-situ variations is plotted in red. Radar refractivity obtained with the targets on towers 1, 2 and 3 are plotted resp. in blue, green and magenta. We observe a very good temporal correlation on this period. On 28th of July, a rainy time period strongly affects refractivity measurements.
Small differences between radar measurements can be observed at smaller time scale.

Conclusions and Perspectives

With the French radar network dataset we demonstrated the possibility of establishing a quantitative and qualitative link between radar refractivity variability, AWS refractivity variability and low-level atmospheric turbulence.

The following analysis of the dataset from TeMeRAiRE will allow us to do:

1. a comparison between the 3 in-situ stations in order to determine when refractivity measurements are affected by small scales processes,
2. a comparison between hectometer radar refractivity and in-situ measurements,
3. an evaluation of the refractivity obtained by spatial differentiation between two targets,
4. a study of the under-sampling effect on the radar and in-situ refractivity measurements.

References:

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