Impact of the city on fog predictions between countryside and urban airports

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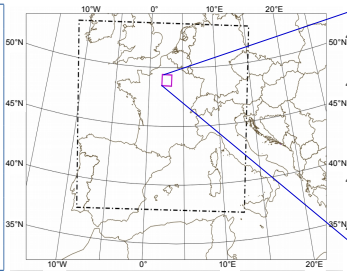
Abstract

Numerical fog predictions are carried out over Paris and suburbs including the Roissy Charles-de-Gaulle (CDG) (countryside airport) and Orly (urban airport) to study the effect of the city on fog predictions. Simulations on 150*150km domain are performed with a specific configuration of the operational meso-scale model AROME. The formation of radiative fog appears north of Paris (countryside). Once set, it is advected over Paris and transformed into low clouds thanks to the turbulence and the heat flux produced by the city. Paris impacts strongly the formation and the evolution of fog around the city. During the dissipation phase, no real impact is detected on fog properties.

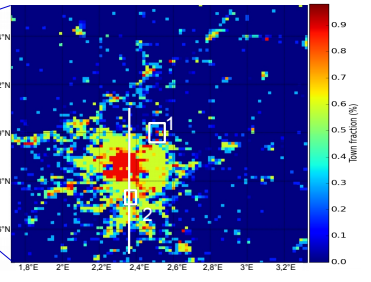
Description of model and numerical experiments

In this study, simulations are carried out with a specific AROME configuration based on the operational AROME-France. Simulations are realized with a 120*120 grid points domain centered on CDG airport with a 1.3-km horizontal resolution and three different vertical resolutions, 60, 90 and 156 vertical levels. The case study simulations are initialized at 1200 UTC (+1 hour in winter local time) the 22nd of October 2012 for a 30 hours simulation. The white squares "1" and "2" correspond respectively to the studied areas of CDG and Orly. The straight white line represents the studied vertical cross-section. Simulations are compared with visibility and ceiling cloud observations collected at both airports. Numerical forecasts features are summerised below.

Study domain	120*120 grid points over CDG and Orly airports
Horizontal resolution	1.3km
Host model	AROME-France
Radiation scheme call	Every 3 minutes
Turbulence scheme intensity	Tuned
CDG Vertical profiles	Averaged over 28 grid points
Orly Vertical profiles	Averaged over 20 grid points
Vertical resolution	60, 90 and 156 levels
First level	10m, 5m and 1m
Outputs	Every 3 minutes
Simulation duration	30h starting at 1200 UTC



Dashed black square : host model
Solid pink square : studied domain

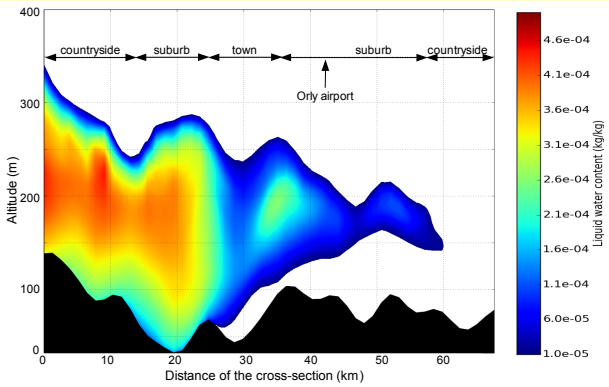


Normalized town fraction percentage of the calculation area

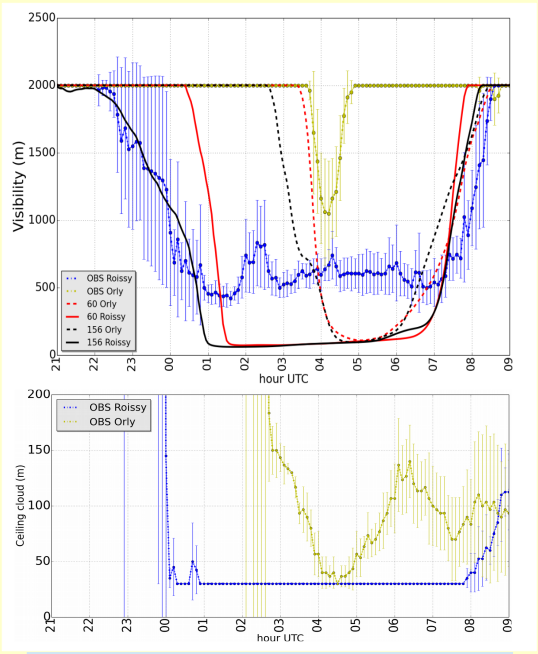
Fog features variability between countryside and urban airport

Fog appears around 2200 UTC the 22nd of October over clear sky and light wind conditions at the North of Paris. The location of airports (countryside or urban) involves differences on the formation and evolution processes. In overall, the spatial and temporal evolution of the fog episode is well represented by the model.

At CDG airport (countryside, north of Paris), radiative cooling during night diminishes the air temperature close to the ground and saturation occurs with an appropriate turbulent mixing and specific humidity. This phenomenon occurs with an equilibrium between these characteristics which can be altered by the surrounding air. The model represents well this phenomenon and much better with finer resolution close to the ground. The fog layer is advected toward Paris by the wind and lifted up thanks to the turbulence produced by the city. Clouds are afterwards advected over the city to reach Orly airport (urban, south of Paris) a few hours later. From observations at Orly airport, low clouds do not reach the ground, with visibilities always above 1000m and a cloud ceiling around 50m high. At Orly airport, the radiative cooling at the top of the cloud together with the turbulence are key processes to the evolution of low clouds. The model produces a radiative cooling at the top of the cloud, which involve lowering of cloud. The air flow mixing redistribute the heating lost downwards, which cooled down the air layer below the cloud and decrease the condensation level. This phenomenon is altered by the upwards heat flux of the city. These upwards heat flux are weaker once the low cloud reached Orly airport, and could explain the cloud base lowering simulated by the model.



Vertical cross-section of liquid water content along the longitude axis at 0300 UTC



Visibilities over ground at Roissy and Orly airports. Blue and yellow curves correspond to the visibility observations respectively at Roissy and Orly with their standard deviation. Black and red curves correspond to visibility computed with Kunkel's algorithm (1984) for high and low vertical resolution – Solid and dashed lines represent respectively Roissy and Orly airports

This study shows that between two different location features airports (countryside and urban), the dynamical and physical processes are not the same, and more or less impacted by the city. Turbulence and heat flux produced by the city modified fog episodes created around and could strongly impact the fog predictions especially at urban airport like Orly.