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Near-Field Pollutants Dispersion in a Stratified Surface Layer: Comparison of Numerical Study and Field Measurements of SIRTA

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Introduction

In order to study pollutants dispersion in **a stable atmospheric boundary layer**, an experimental program consisting in measuring **turbulence fluctuations** and **pollutants dispersion** in **a stratified surface layer** and in **near field** is being conducted on the site 'SIRTA'. Numerical simulations are performed by using an open source CDF code *Code_Saturne* in RANS mode with standard *k-ε* turbulence model. Stable thermal stratification and tracer gas release during an IOP on 5 June 2013 are taken into consideration. A drag porosity model introduced in Zaïdi et al. (2013) has been applied to the forest area. Pollutants dispersion has been modelled by a transport equation model described in Milliez and Carissimo (2008).

SIRTA dispersion experiment

The campaign is carried out in Zone 1:

- **Forest** to the north: parameterized by **leaf area density α**
- **Source** (at 3m height)
- **12 ultrasonic anemometers**:
  - Continuous measurements: wind speed and temperature at 10 Hz
  - At 3m height: NW, NE, SW, SE, 20N, 10N, 0, 10S, 20S
  - Two masts: 10mSW, 10mSE and 30mSE
- **6 photo ionization detectors (PIDs):**
  - Measurements during tracer tests: concentration at 50Hz
  - All at 3m height

(a) (b)

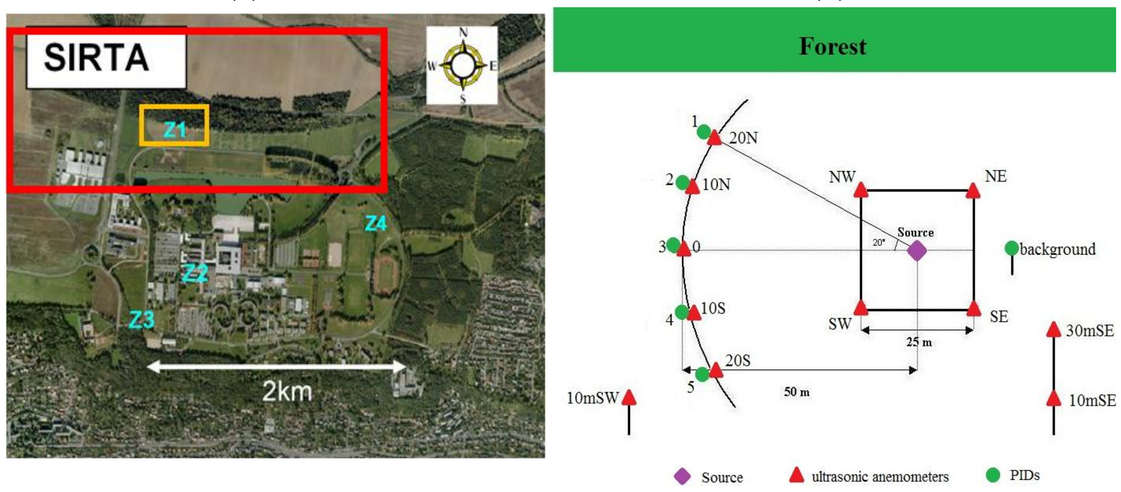
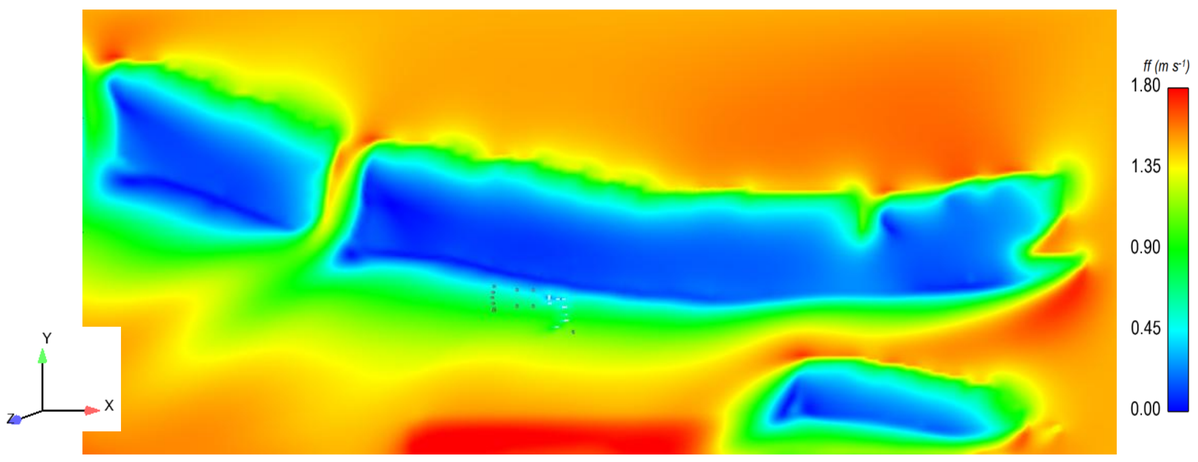


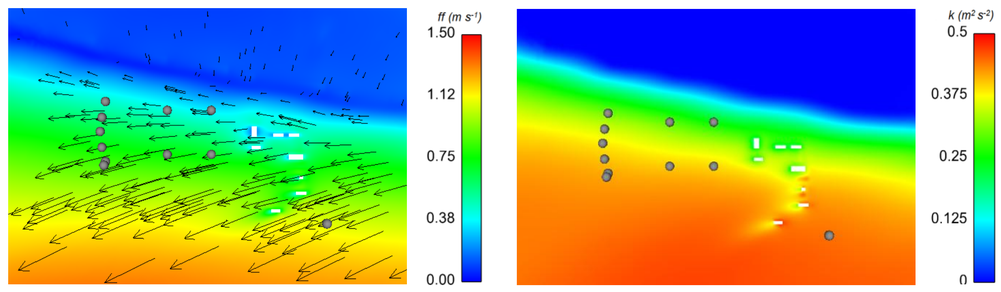
Fig 1 (a) Whole measurement area in the SIRTA field (big red rectangular: modelling area; small yellow rectangular: instrumental area) and (b) sensors positions in Zone 1

Numerical simulations

The **IOP on 5 June 2013** has been chosen to present the results because of better quality in PIDs measurements. During the IOP **(from 19:08 to 20:08)** , wind is slightly south-east with velocity around 1.5 m/s at height of 3 m. Inlet conditions are generated with measurements of 10mSE and 30mSE during the IOP: wind direction = 58°, wind velocity = 3.5 ms^{-1}, L_{MO} = 130 m and z_0 = 0.3m.



Velocity field at z = 3m



Velocity field at z = 3m

TKE field at z = 3m

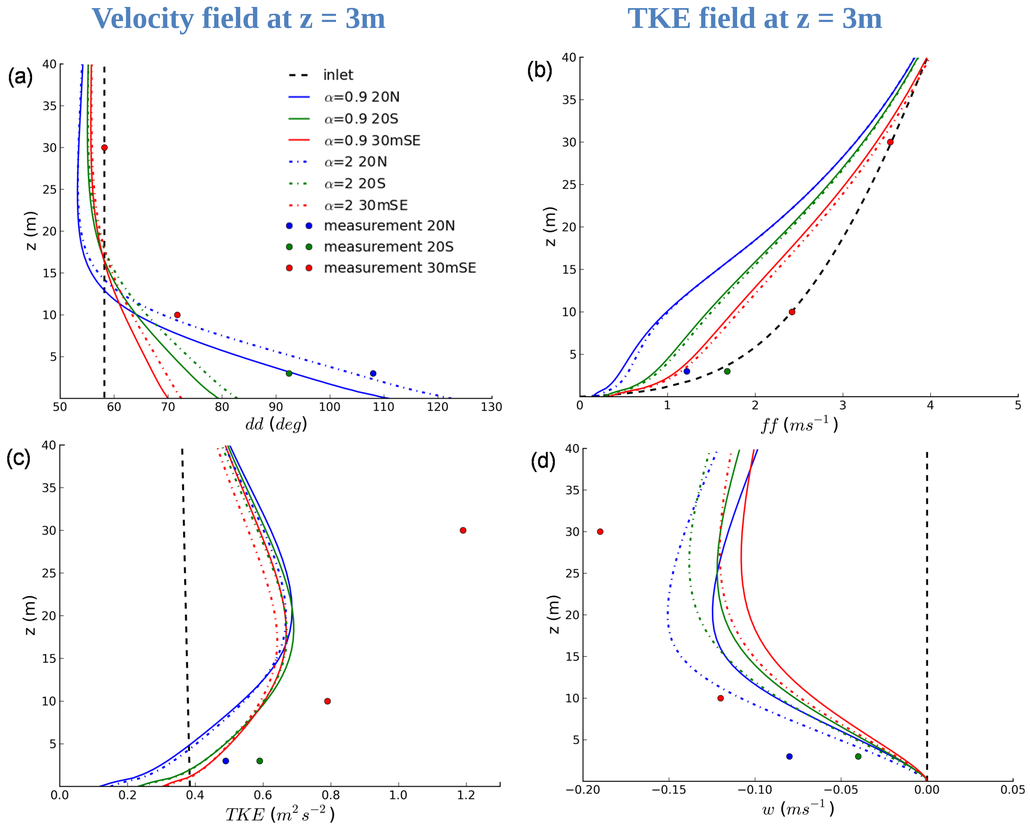


Fig 2 Comparison of vertical profiles of (a) horizontal wind direction, (b) horizontal wind speed, (c) TKE and (d) vertical velocity between simulations and measurements for the IOP on 5 June 2013 ; 'dashed line' – inlet condition; 'solid line' – simulations with α=0.9; 'dash-dot line' – simulation with α=2; **the low level wind rotation is stronger for larger leaf area density**

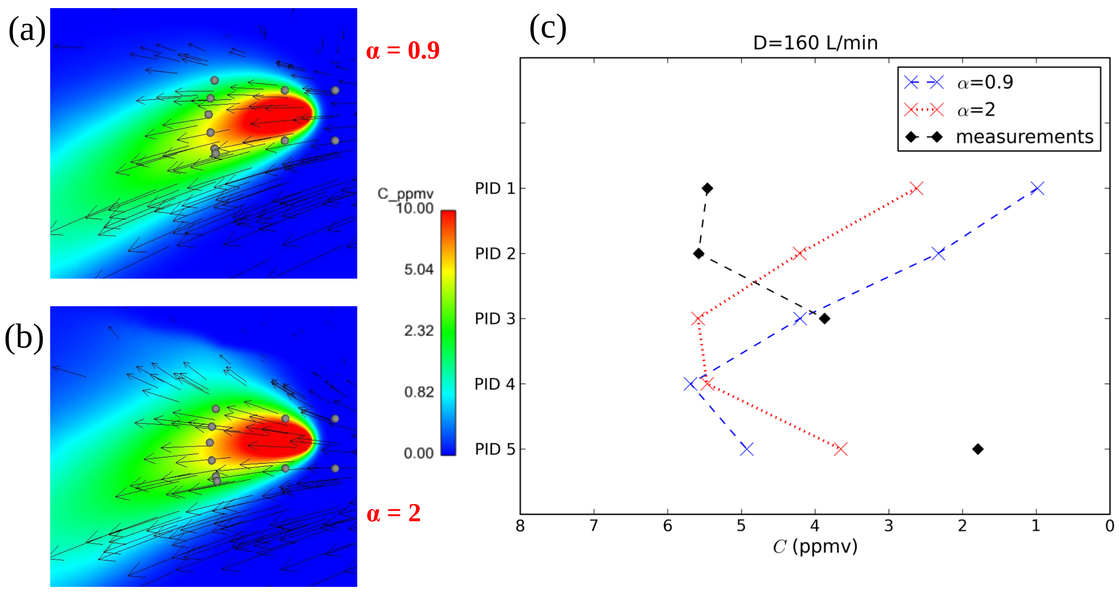


Fig 3 Simulation results for the IOP on 5 June 2013 at 3m height: mean concentration for (a) α=0.9 and (b) α=2, (c) comparison of mean concentration between measurements and simulations with α=0.9 and 2

Conclusions

- Impact of terrain heterogeneity: perturbation from the forest → slowing down of wind, change of wind direction, generation of high TKE above and downstream
- Numerical simulation with Code_Saturne can reproduce the mean flow, turbulence and pollutants dispersion for the SIRTA site with a slight underestimation of the wind rotation by the forest
- Correct mean concentration, given the difference in wind rotation

References

Milliez M and Carissimo B (2008) Computational fluid dynamical modeling of concentration fluctuations in an idealized urban area. Boundary-Layer Meteor., 127: 241-259.

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Zaïdi H, Dupont E, Milliez M, Musson-Genon L and Carissimo B (2013) Numerical simulations of the microscale heterogeneities of turbulence observed on a complex site. Boundary-Layer Meteor., 147: 237-259.