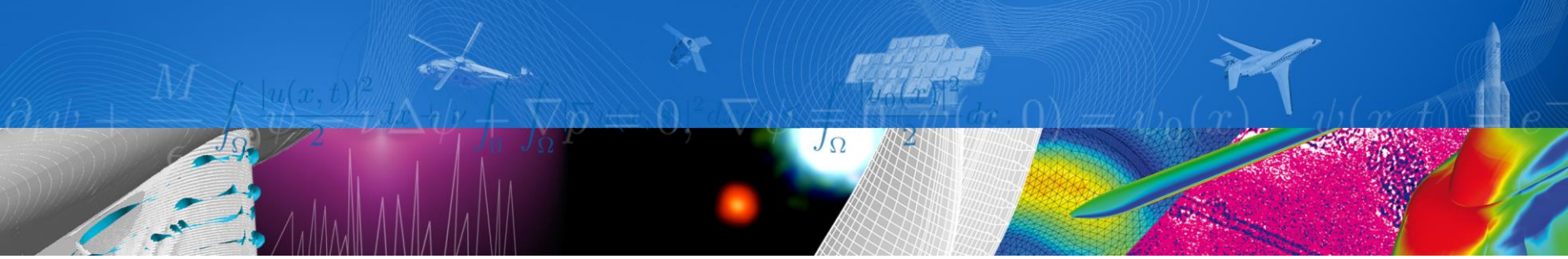

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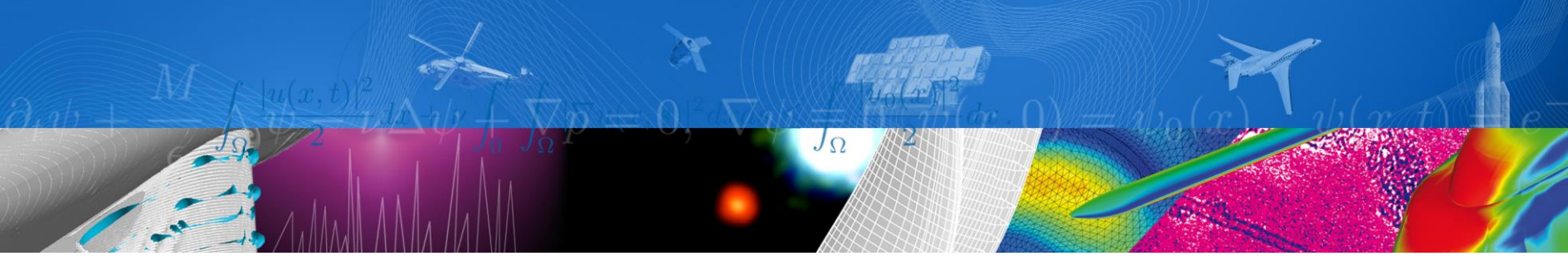

# Simulation of Aircraft emissions dispersion by tracking aircraft using CFD

**W. Ghedhaïfi, E. Montreuil and E. Terrenoire**
**weeded.ghedhaifi@onera.fr**

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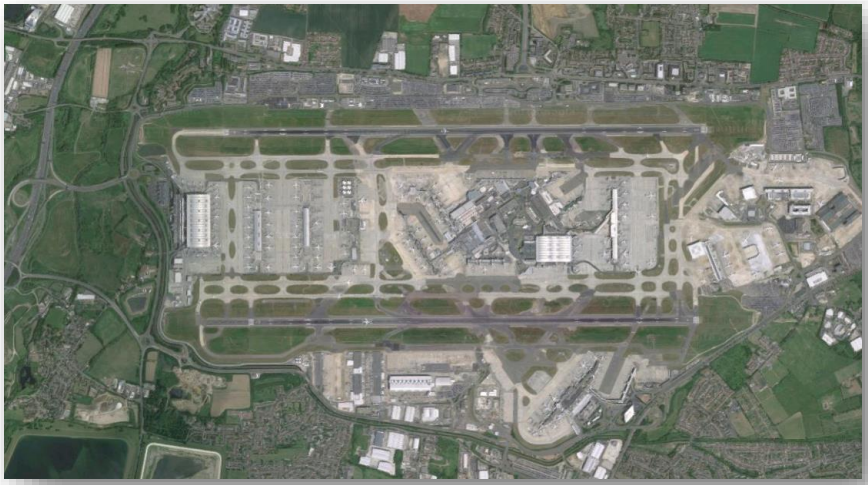
# General context: Environmental impact

**Local Airport Air Quality**

(Airport Platform)

# Objectives

**Local Airport Air Quality**
(Airport Platform)



**High spatial and temporal resolution**

**Second → day**

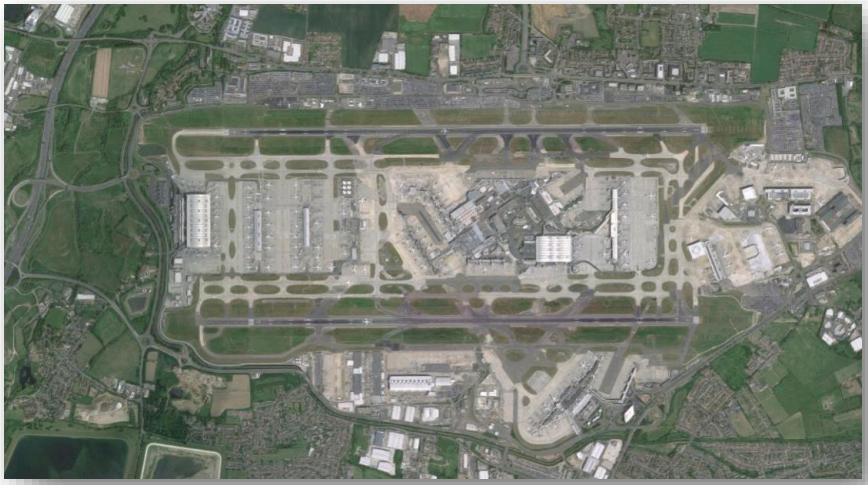
**Meter → Kilometer**

**Small Scale Phenomena**
**Local Impact**

- **Identify conditions leading to high pollutant concentrations**
  - Particular meteorological conditions
  - Buildings effects
- **Improve prediction capabilities**
- **Evaluate mitigation solutions**

# Considered data (here)

**Local Airport Air Quality**
(Airport Platform)



Meteorology

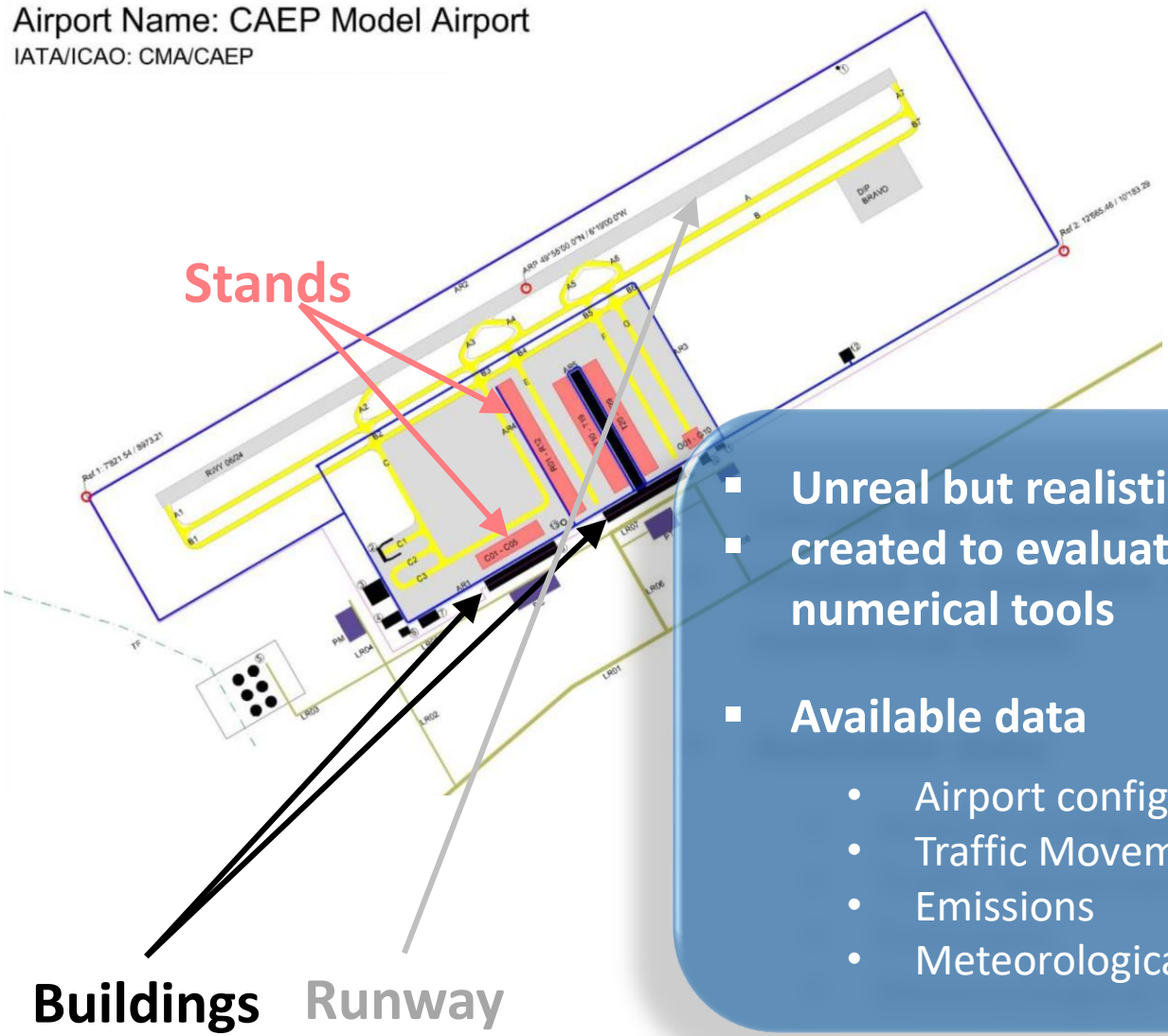
Aircraft emissions

**Simulation/modelling of emissions dispersion**

Trajectories

Background Concentrations

# Airport model : CAEPport




- **Unreal but realistic model**
- **created to evaluate Airport Air Quality numerical tools**

- **Available data**
  - Airport configuration
  - Traffic Movements
  - Emissions
  - Meteorological data



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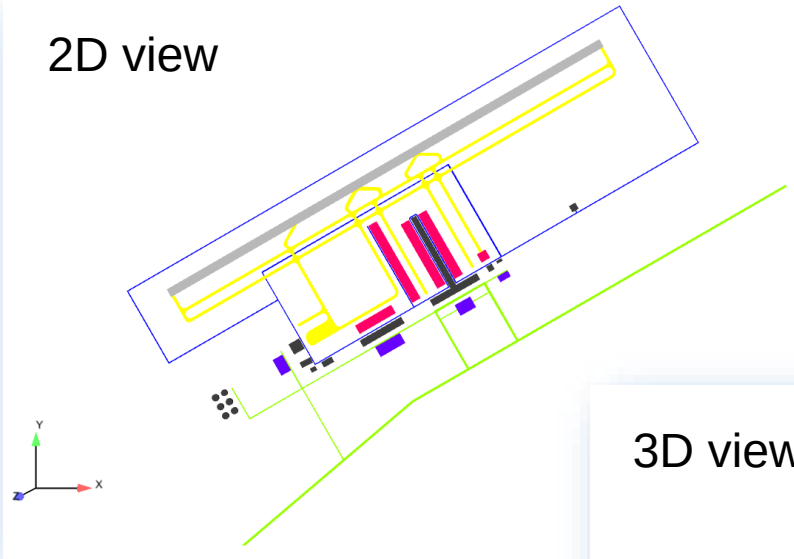
# Numerical code

## ONERA in-house CEDRE code

- Navier-Stokes compressible non structured solver
- RANS Approach
- Turbulence Model : $k - \omega$ SST
- Non reactive chemical species (1st approach)
- Moving emission sources (aircraft)

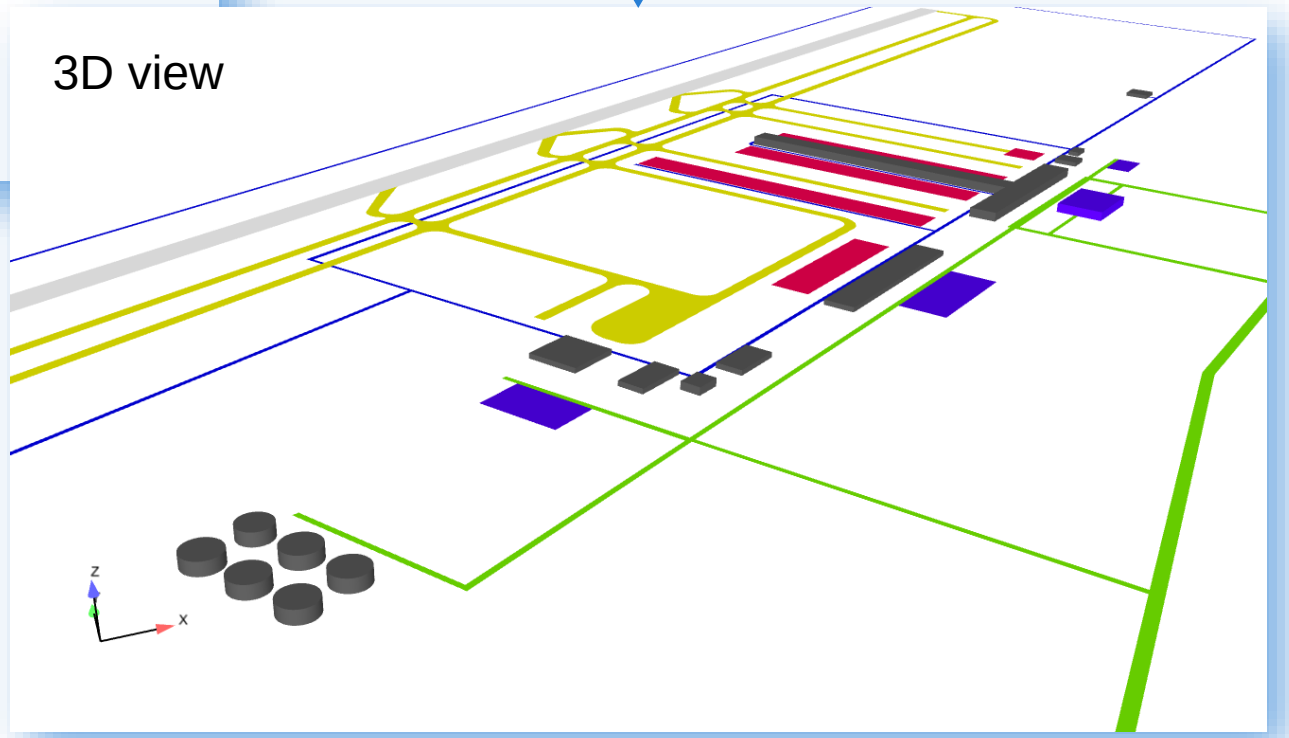
# 3D CAD of the CAEPport created from the 2D plan

2D view



**3D CAD designed using CATIA software**

3D view





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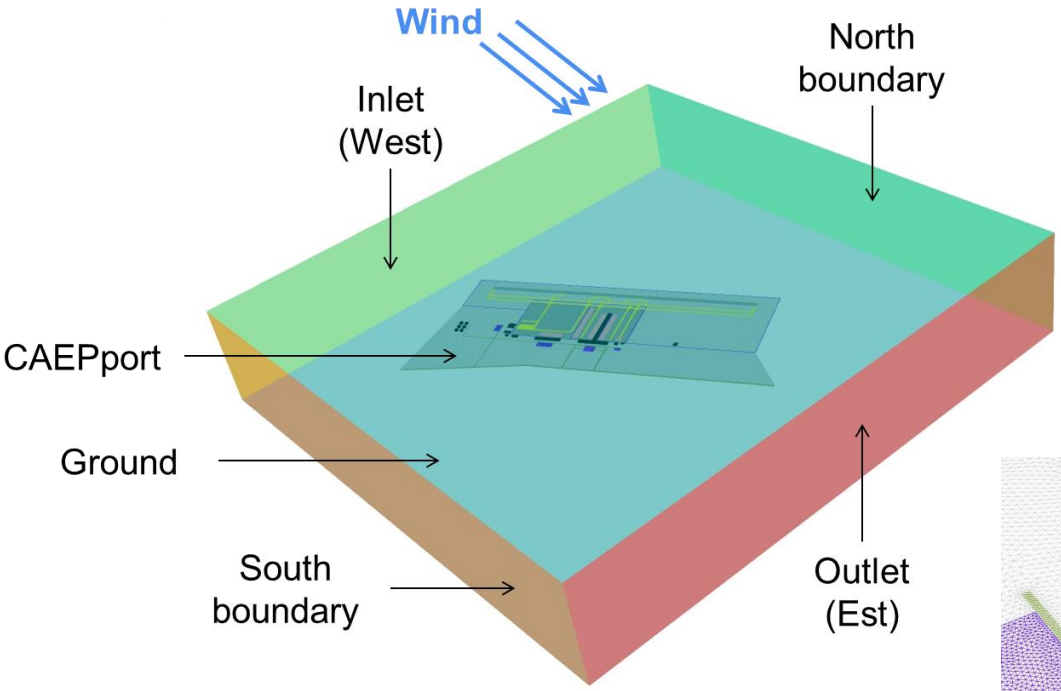
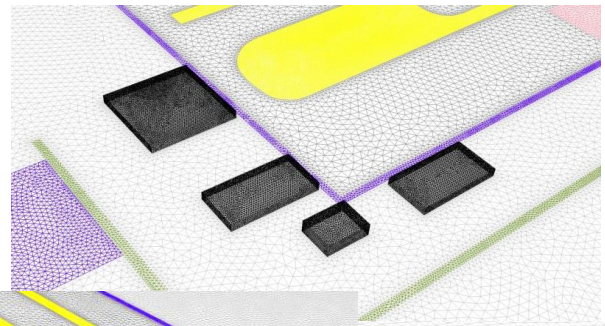
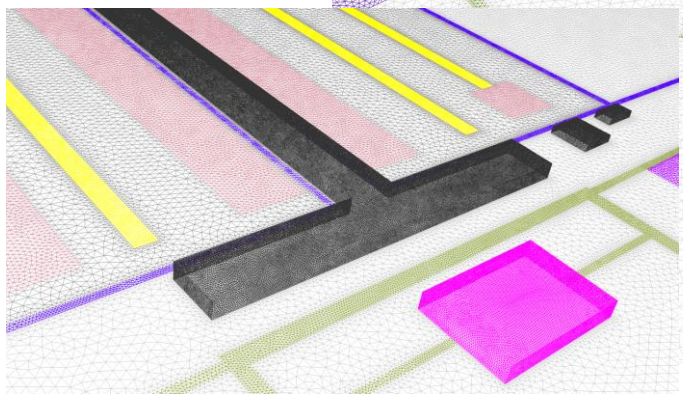
# Numerical setup

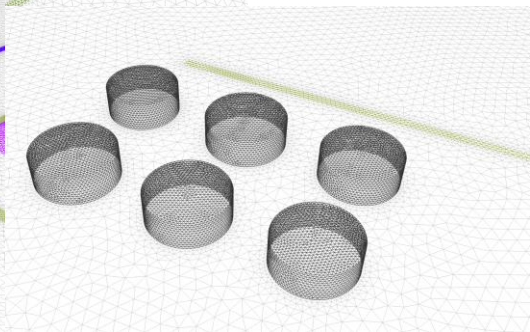



Computational domain

- Height: 1500 m
- Width: 8000 m
- Length: 8000 m



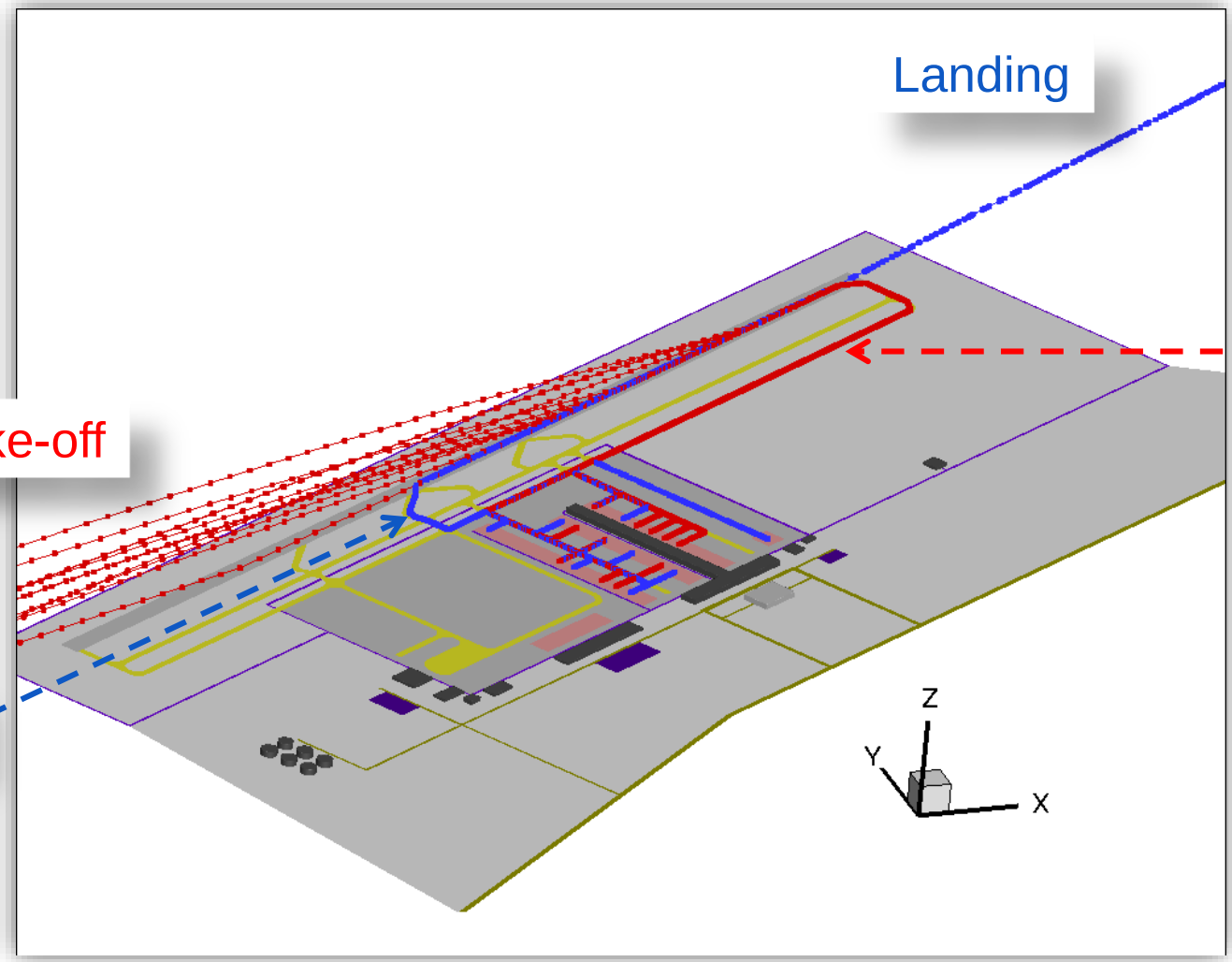




Mesh

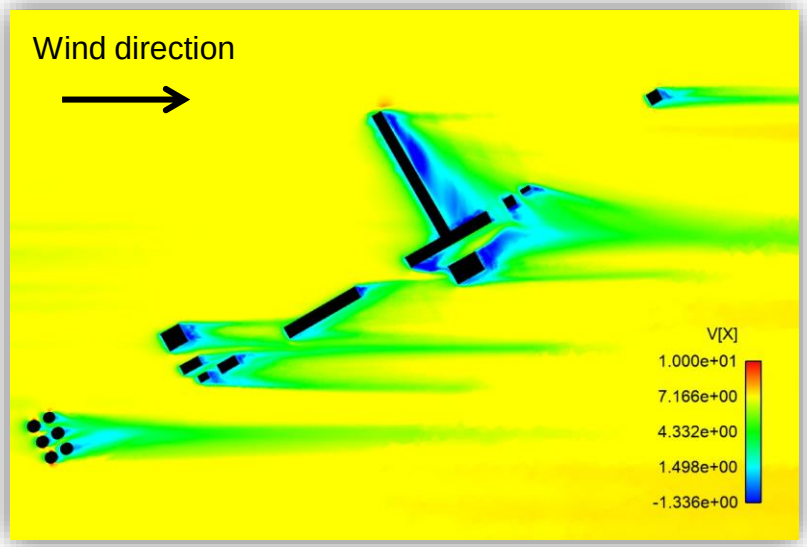
- 12.4 million cells
- Tri and tetra elements

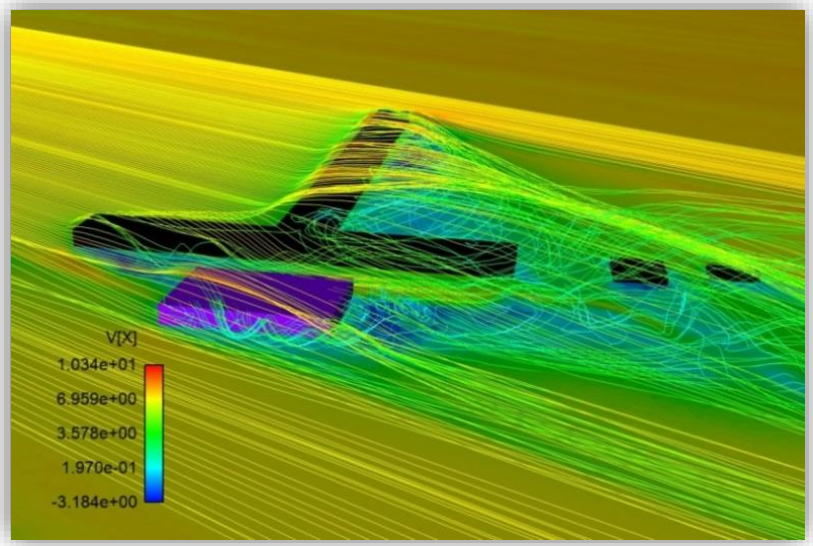
# Aircraft trajectories

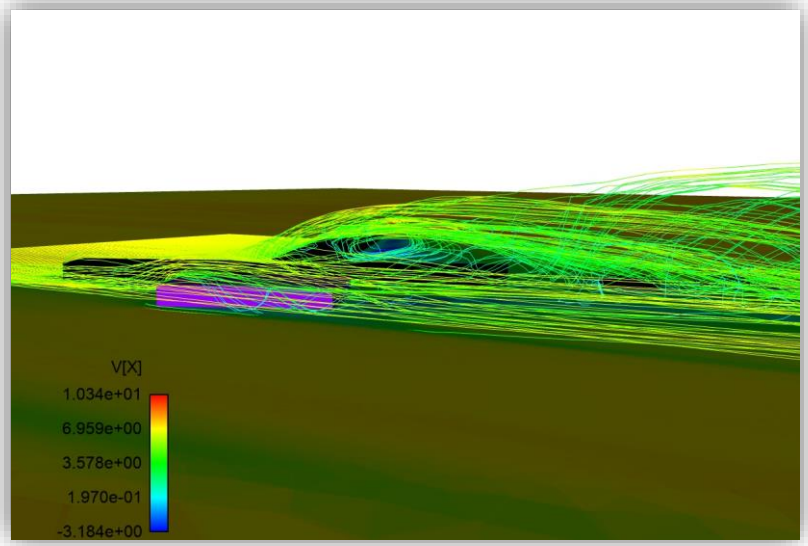


# Flow around buildings

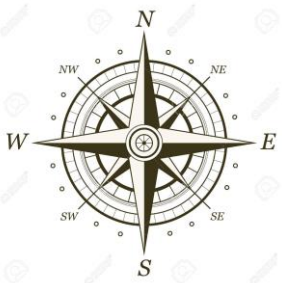
- Horizontal velocity field
- Streamlines



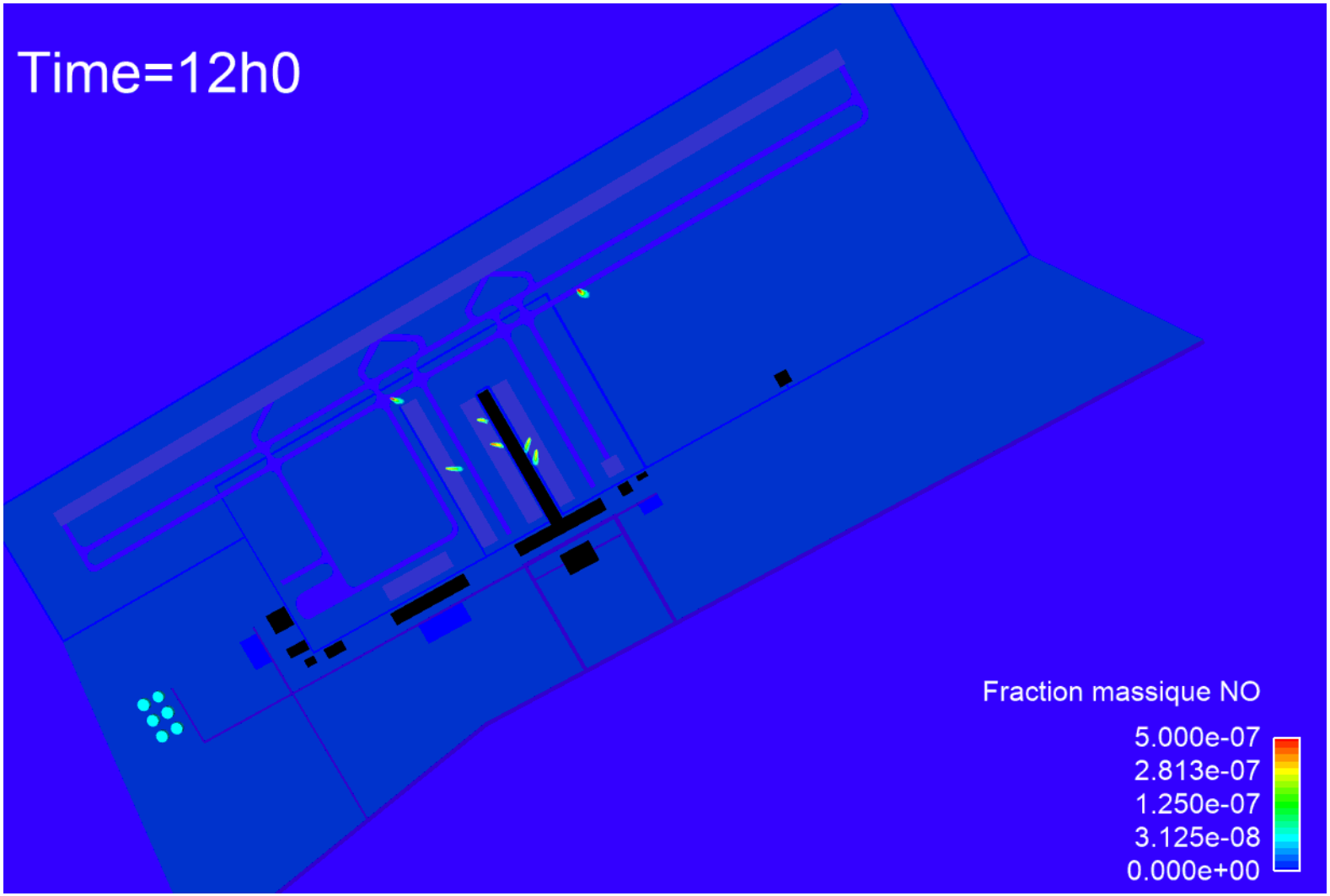



# Emissions dispersion



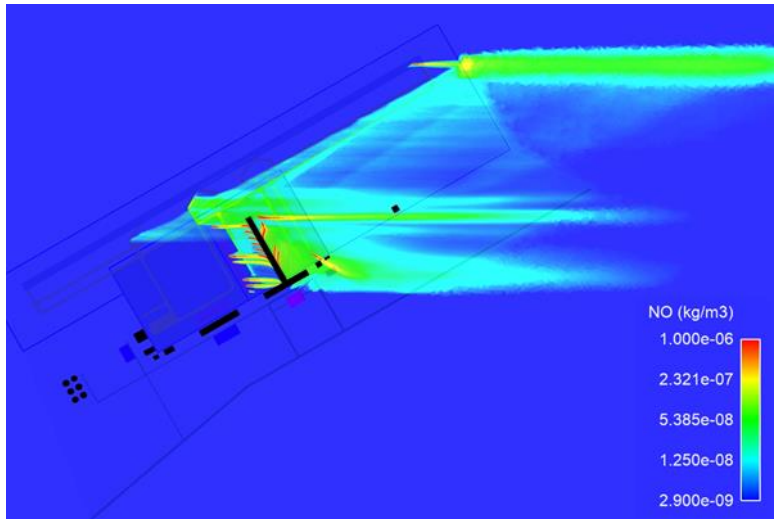

**Wind**

**V = 5 m/s at z = 2 m**

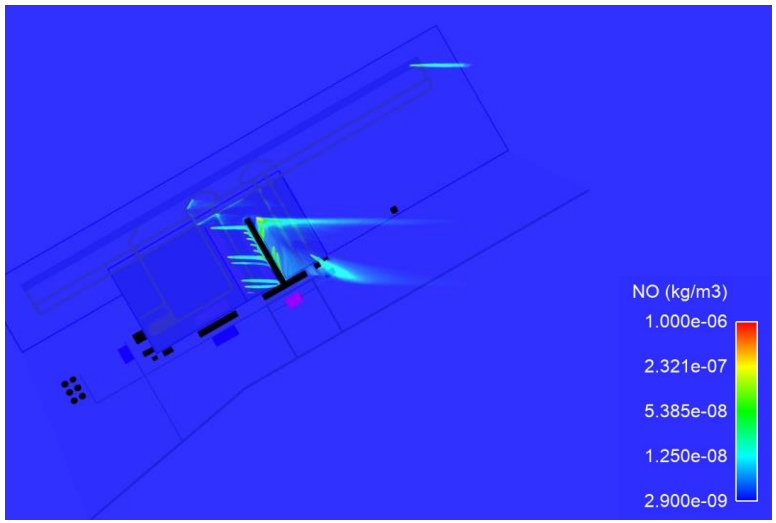



Cut plane at 2 m above the ground

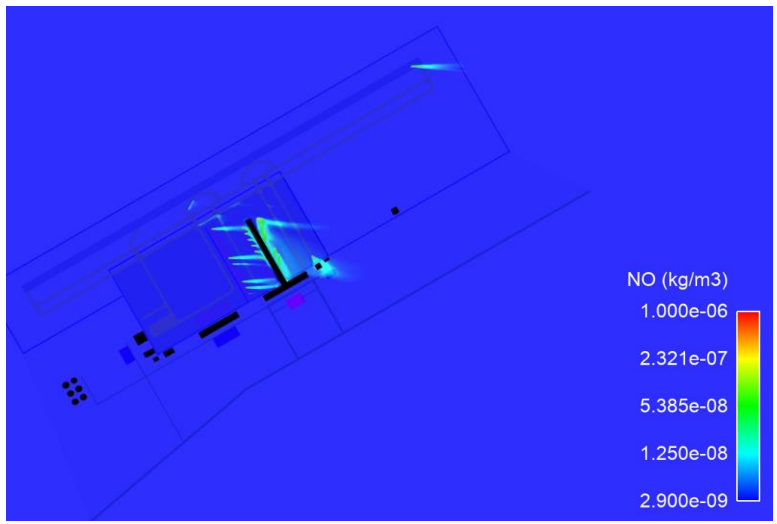
# NO mean concentration fields between 1:00 pm and 2:00 pm




Stable case

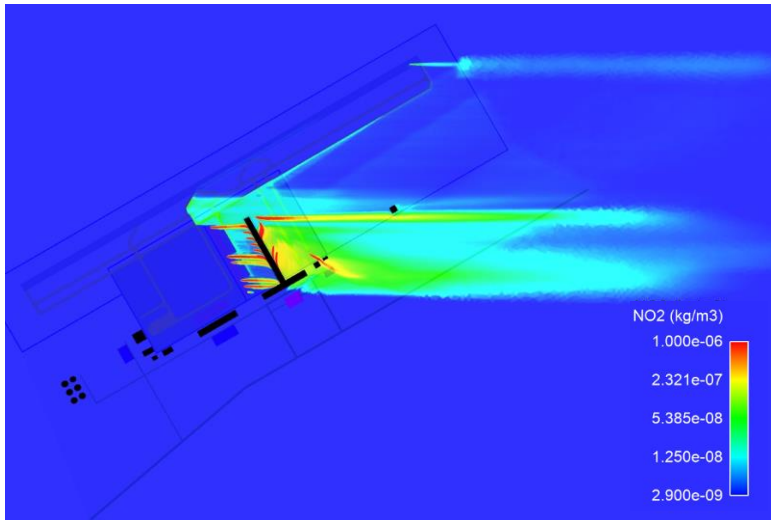



Neutral case

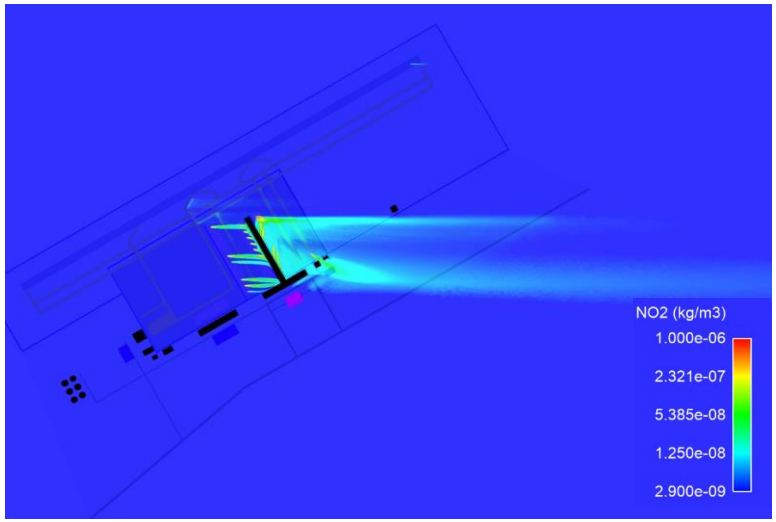



Unstable case

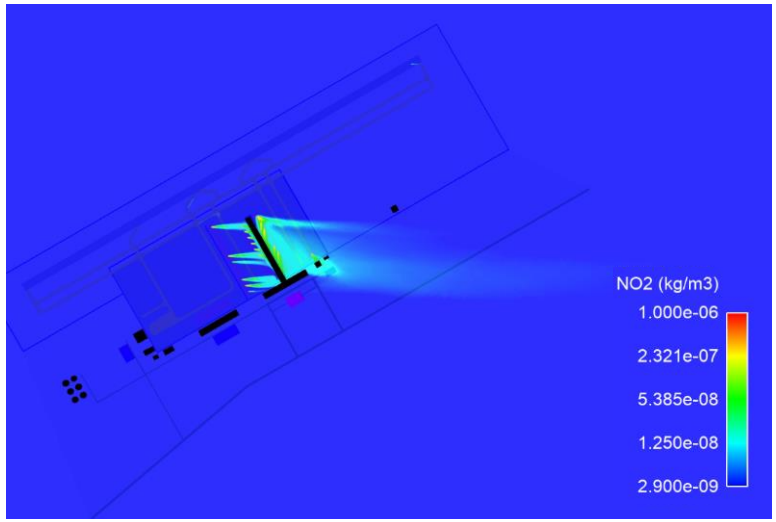
# $NO_2$ mean concentration fields between 1:00 pm and 2:00 pm




Stable case



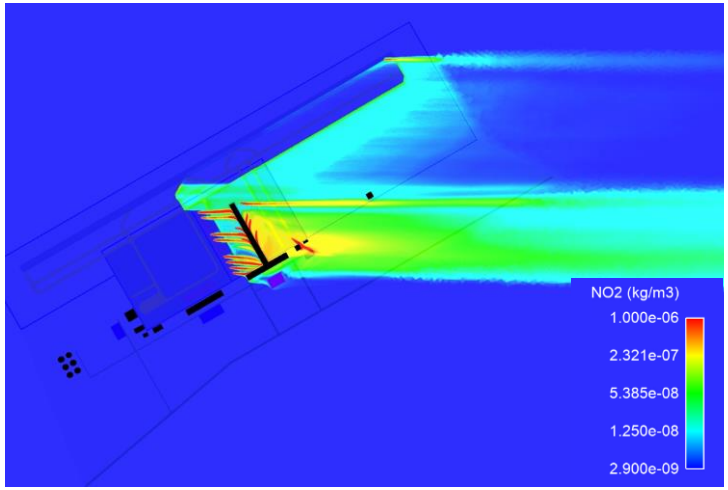
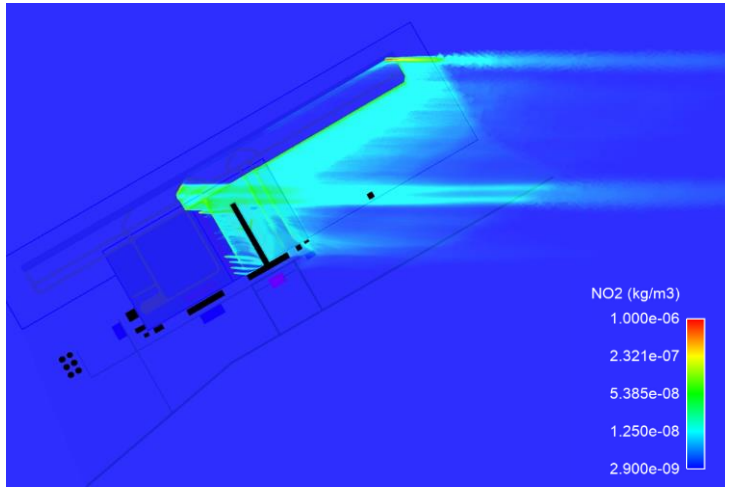
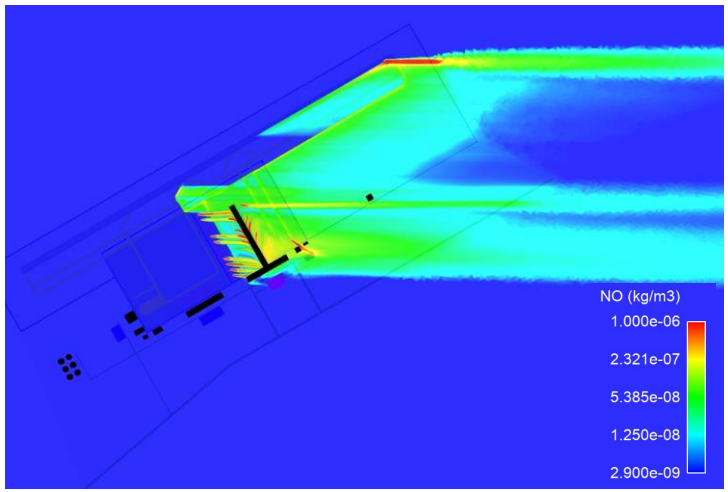
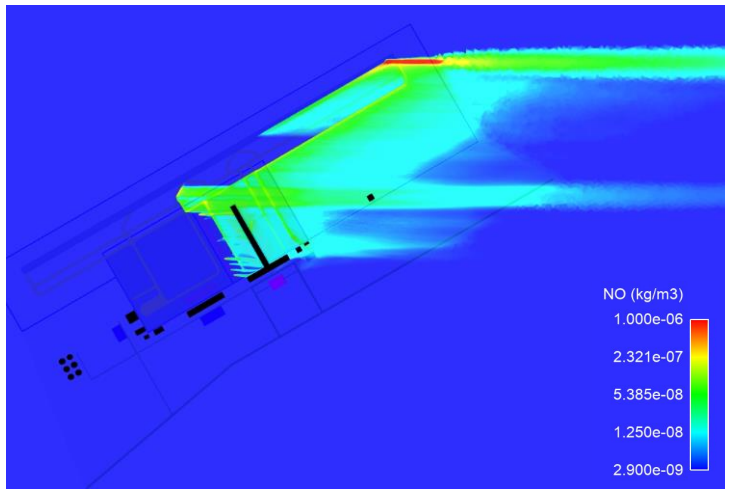

Neutral case




Unstable case

# Parametric study: with and without APU (stable case)

## NO and $NO_2$ mean concentrations between 3:00 pm and 4:00 pm

| | With APU | Without APU |
|---|---|---|
| $NO_2$ |   |   |
| NO |   |   |

# Conclusions and outlook

- **Use of a realistic, even if unreal, airport model: the CAEPport**
- **Numerical modelling and simulation of aircraft emissions dispersion within the considered airport area**
- **Resolution of small scale (spatial and temporal) phenomena**
- **Use of realistic meteorological data and background atmospheric chemical composition**
- **Taking into account Aircraft emissions moving along their own trajectories**

- **Simulate a real airport with emissions from all the contributors**
  - **Distinguish emission sources (aircraft, cars, energy production, etc.)**
- **Take into account pollutants as NOx, $O_3$, PM**
- **Take into account chemical reactivity, ground properties, etc.**
- **Compare numerical results with experimental measurements**
- **Find out mitigation solutions**