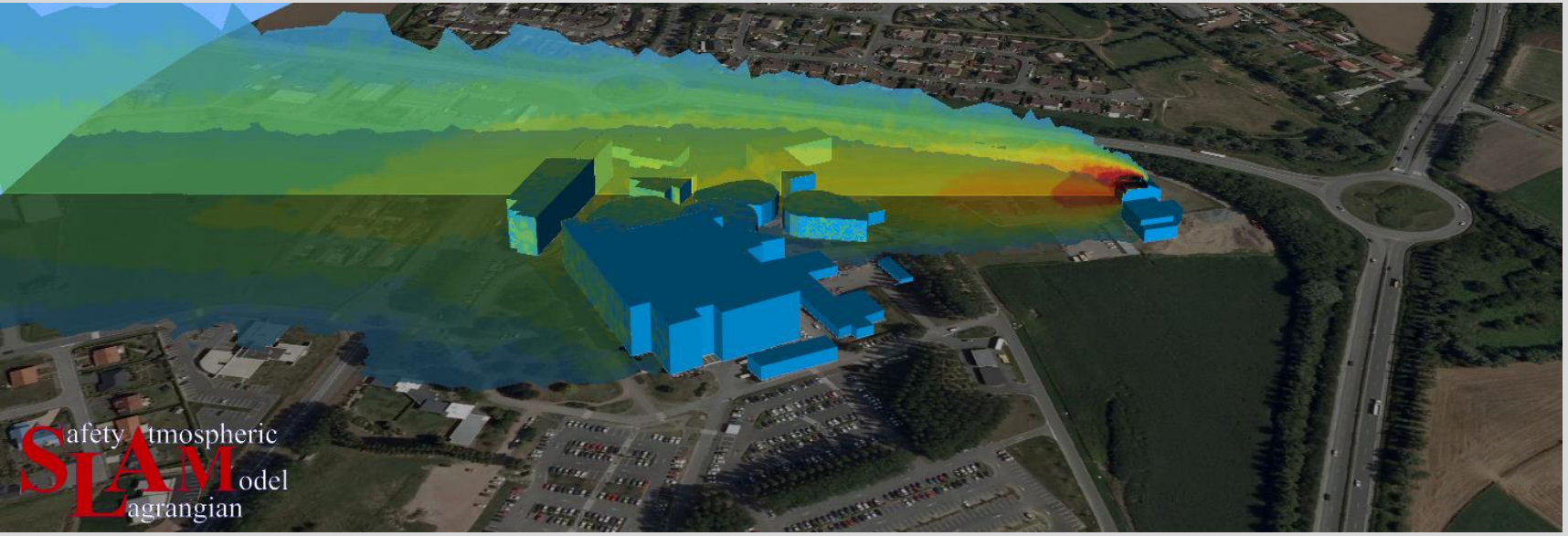
Laboratoire de mécanique des fluides et d'acoustique

AIR Atmosphere Impact & Risk

Pollution de l'air – Dispersion atmosphérique – Risque industriel – Ventilation intérieure

EVALUATION OF A LAGRANGIAN DISPERSION MODEL COUPLED WITH A CFD WIND FIELD DATABASE AGAINST A NEW FULL SCALE ATMOSPHERIC TRACER EXPERIMENT



IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

14th June 2021
20th HARMO conference
Tartu, Estonia

Perrine Charvolin-Volta[2], Chi Vuong Nguyen[2], Lionel Soulhac[1], Guillevic Lamaison[2],
Philippe Laguionie[3], Olivier Connan[3], Johann Chardeur[3], Olivier Cazimajou[3], Luc Solier[3], Irène Korsakissok[3], Sophie Vecchiola[3], Anne Mathieu[3], Malo Le Guellec[4], Amita Tripathi[4].
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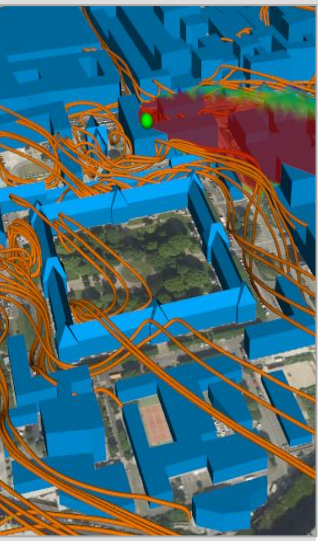
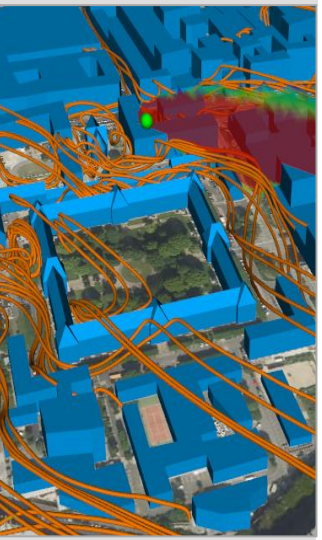
THE DIFLU PROJECT



- Context and objectives
  - Improving and evaluating atmospheric dispersion models in the vicinity of obstacles and buildings are **important challenges**
    - Impact assessment of pollutants in urban areas
    - Risk prevention and emergency response
  - DIFLU project ”Dispersion du Fluor 18 en Milieu Urbain” study the **near field dispersion** of a gas emitted in an urban or industrial environment

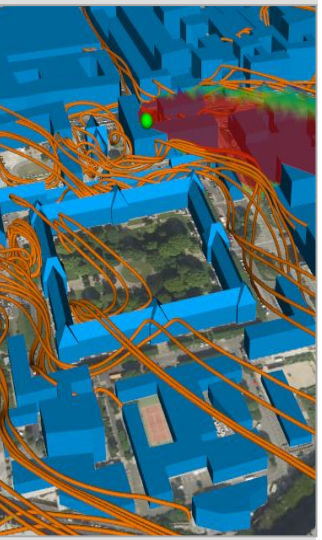
THE DIFLU PROJECT

- Context and objectives
  - IRSN has performed a **full scale atmospheric tracer experiment**, using helium tracer, in the first 200 meters around a **cyclotron**
  - Measured concentrations, for a variety of atmospheric stability conditions, constitute a **new original dataset** for the validation of atmospheric dispersion models at short distance of buildings
  - **Compare the results obtained with the SLAM** (Safety Lagrangian Atmospheric Model) model against the DIFLU experiment dataset



THE DIFLU PROJECT

- Partners

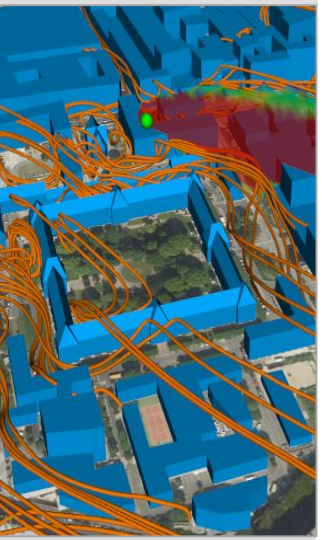


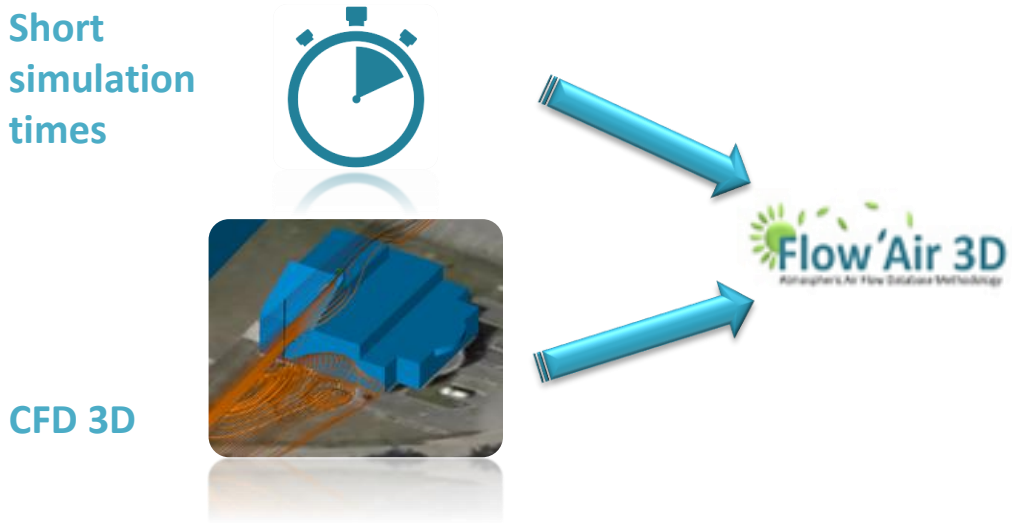
H20-058 – Session 11 – Topic 6

Dispersion of radionucleides in a urban environment (DIFLU) : comparison of numerical results with experimental measurements

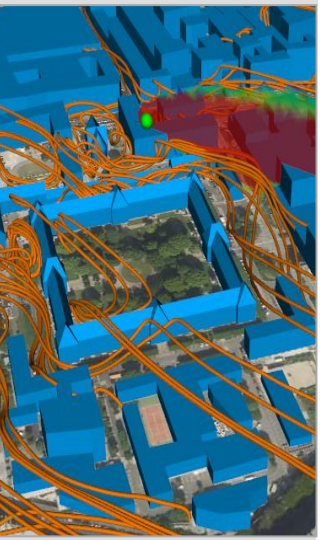
LAGRANGIAN MODEL-CFD COUPLING

- Flow'AIR 3D Methodology – Objectives :
  - Developed by the AIR team of LMFA for ten years in a research program on the development of a methodology aimed at using the **3D CFD** approach in an **operational context**, with a robust and validated approach and **short simulation times**





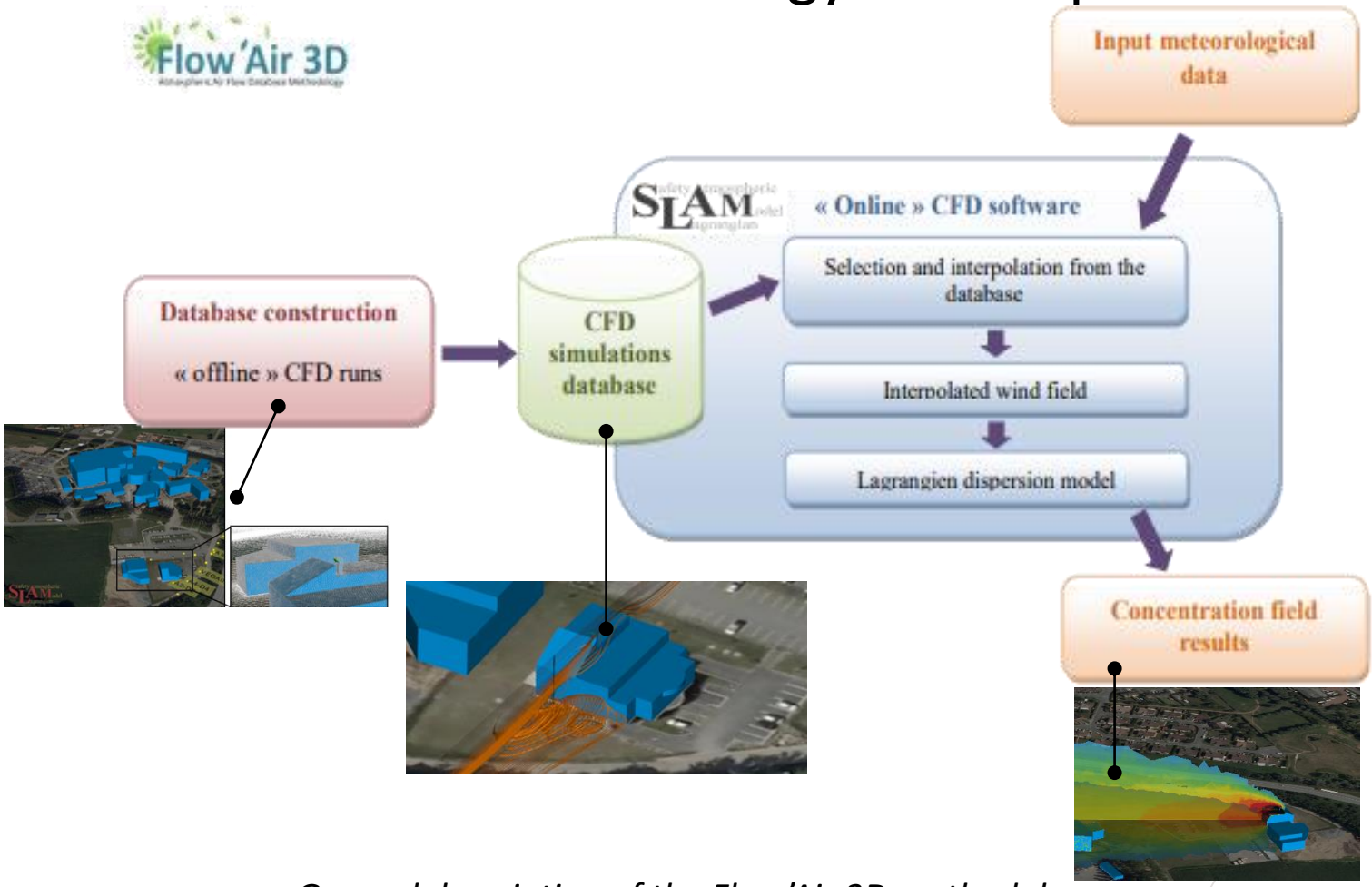
LAGRANGIAN MODEL-CFD COUPLING



- Flow'AIR 3D Methodology – Principe :
  - Make in advance a **database of wind fields** on the considered industrial site. Only the dispersion is modeled in operational situations and time savings is considerable
  - Parameters that constitute the database : **wind direction, friction velocity u* and the inverse of the Monin-Obukhov length**
  - **Discretization of the database in 18 wind directions** and **7 values of 1/LMO** can limit the interpolation error in the database to a few percents. Once the database is done, it is **used as input for the Lagrangian model SLAM**

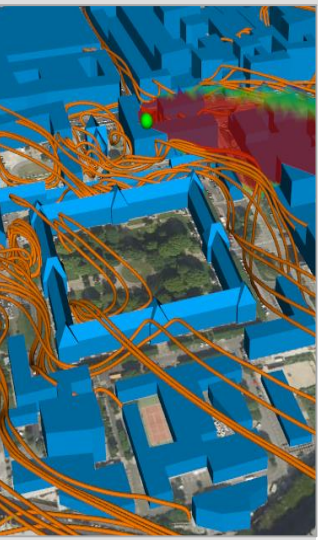
LAGRANGIAN MODEL-CFD COUPLING

- Flow'AIR 3D Methodology – Principe :

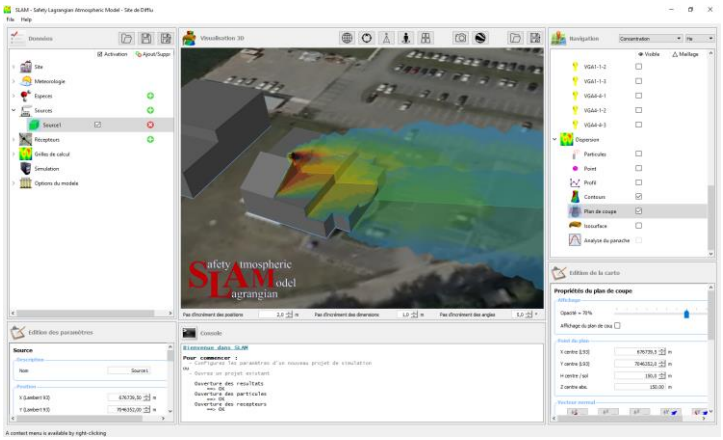


General description of the Flow'Air 3D methodology

LAGRANGIAN MODEL-CFD COUPLING

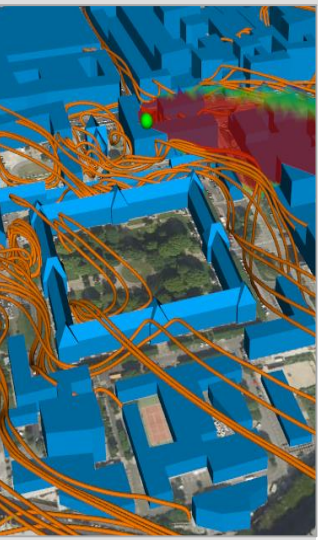


- Lagrangian model SLAM – Presentation
  - Developed by LMFA for ten years
  - A lagrangian stochastic particles dispersion model (Vendel et al., 2011, Marro et al., 2014), **coupled with a wind and turbulence fields database**
  - **Stationary version** of SLAM, called SLAM_S, has been used in DIFLU



IHM of SLAM_S

DESCRIPTION OF THE MEASURMENT CAMPAIGNS

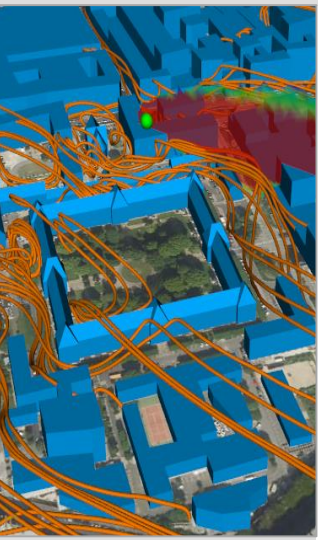


- DIFLU project studies radiological materials produced and partially emitted in the atmosphere by cyclotrons located very close to urban hospitals

- Two **3-day field campaigns** were carried out in October and December 2019 at the **Beuvry hospital site** (France)

H20-058 – Session 11 – Topic 6
Dispersion of radionucleides in a urban environment (DIFLU) : comparison of numerical results with experimental measurements

DESCRIPTION OF THE MEASURMENT CAMPAIGNS

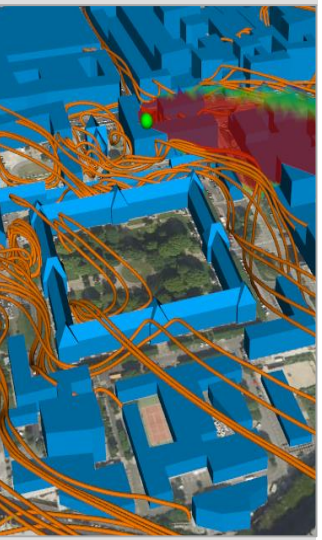


- Dispersion was studied in the near field (<500 m) of the cyclotron

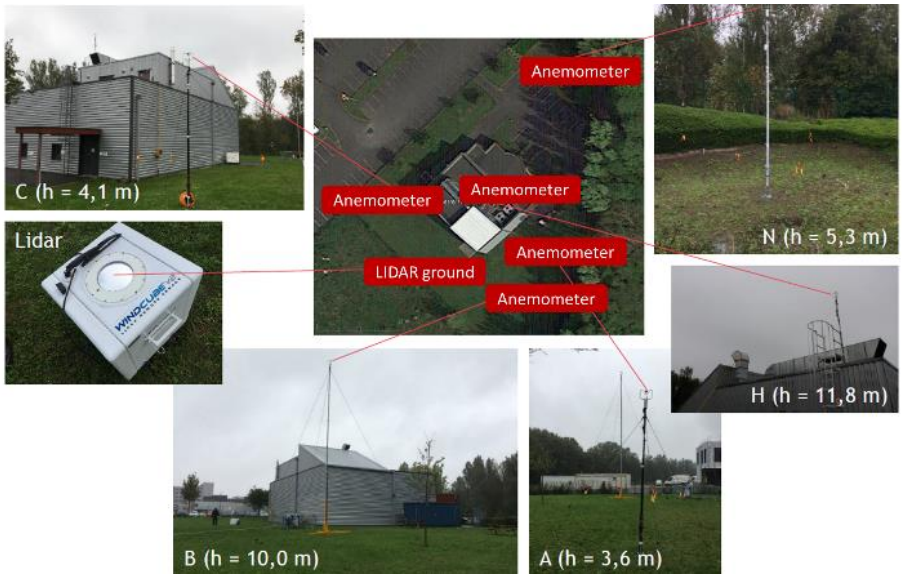
- **19 helium releases** and **395** atmospheric **concentration measurements**

Focus on geometry of the cyclotron's stack

DESCRIPTION OF THE MEASURMENT CAMPAIGNS



- Helium atmospheric concentrations were documented along with meteorological and micrometeorological measurements :
  - One wind LIDAR
  - Five ultrasonic anemometers

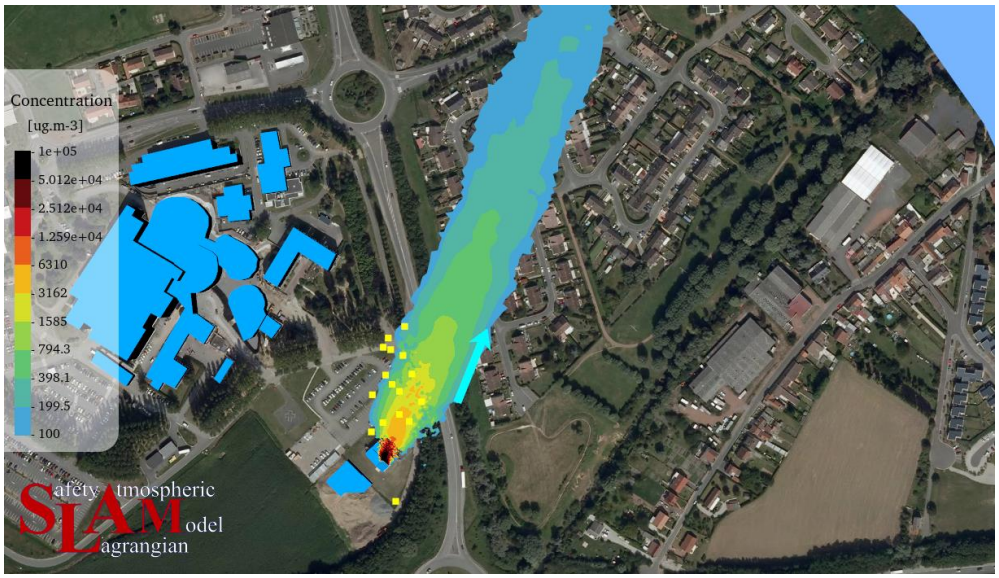


Location of wind LIDAR and ultrasonic anemometers deployed by IRSN

COMPARISONS BETWEEN MEASURES AND NUMERICAL RESULTS

Focus on one scenarii

- During the two campaigns of IRSN, a lot of scenarii of emission due to cyclotron are deployed. Focus on one of them during campaign 1, using anemometer H :



Helium concentration field on the ground calculated by SLAM_S (µg.m^{-3})

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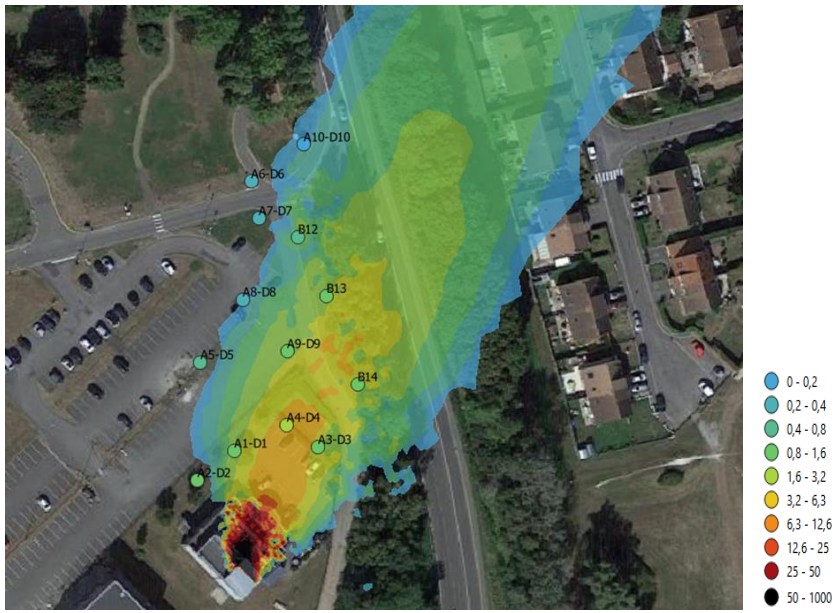


Focus on Helium concentration field on the ground calculated by SLAM_S (µg.m^{-3}) and value measures on captor during experiment (dot)

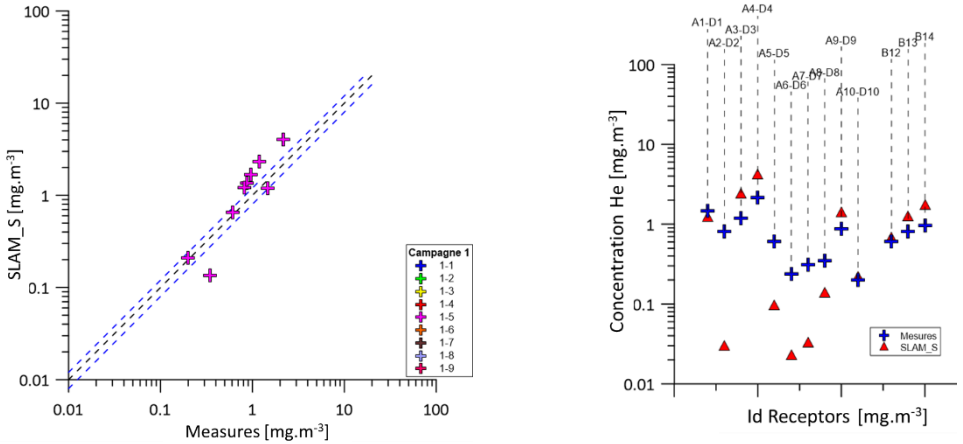
COMPARISONS BETWEEN MEASURES AND NUMERICAL RESULTS

Focus on one scenarii

- During the two campaigns of IRSN, a lot of scenarii of emission due to cyclotron are deployed. Focus on one of them during campaign 1, using anemometer H :

FB	NMSE	ER	R	MG	VG	FAC2
-0.2	0.65	0.8	0.9	1.88	8.62	0.62

Statistics of intercomparison measures-model for one scenario (mg.m^{-3})

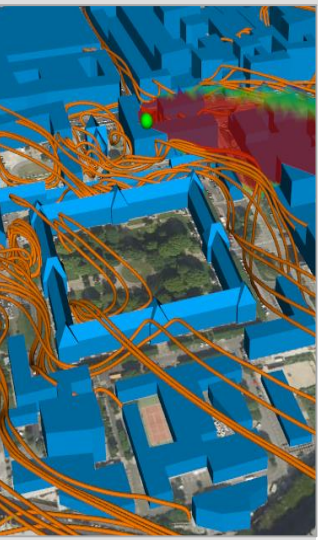


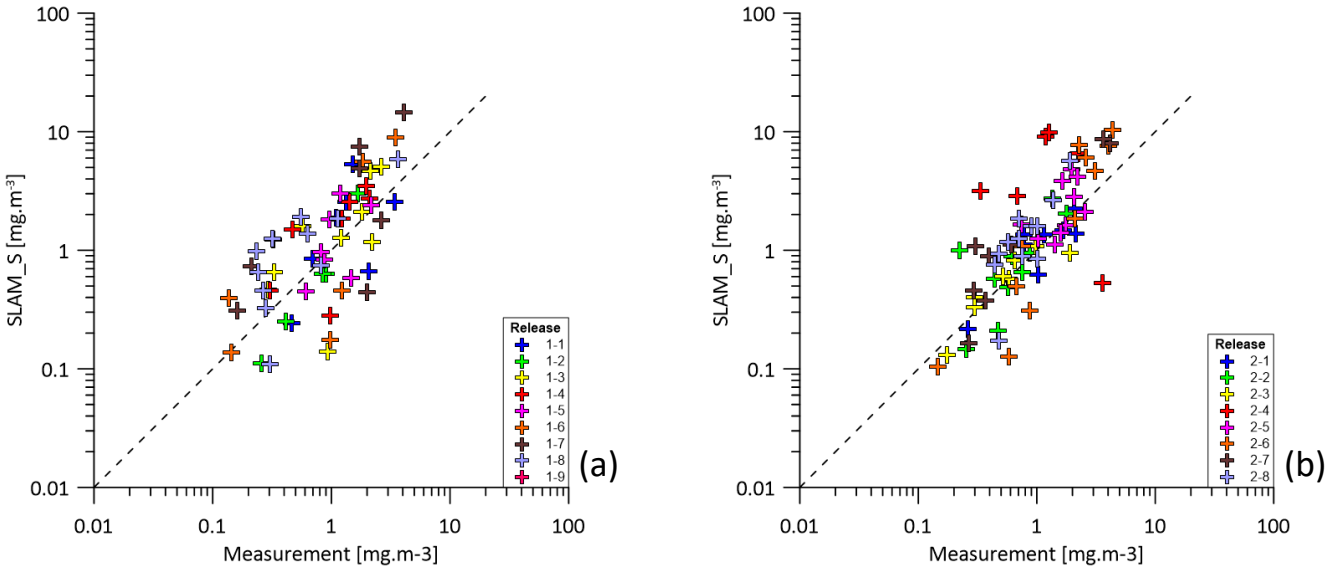
Scatter plot of measures and result of SLAM_S for one scenario on campaign 1 (a) and comparison point to point for each captor EA of IRSN used during experiment (b)

COMPARISONS BETWEEN MEASURES AND NUMERICAL RESULTS

Global analysis and meteorology sensitivity

- For each release, simulations have been carried out with SLAM_S using meteorological data from the anemometer H and the wind LIDAR, respectively





Comparison of concentrations measured and modelled with SLAM_S, using meteorological data ***provided by the anemometer H****, for campaign 1 (a) and campaign 2 (b)*

COMPARISONS BETWEEN MEASURES AND NUMERICAL RESULTS

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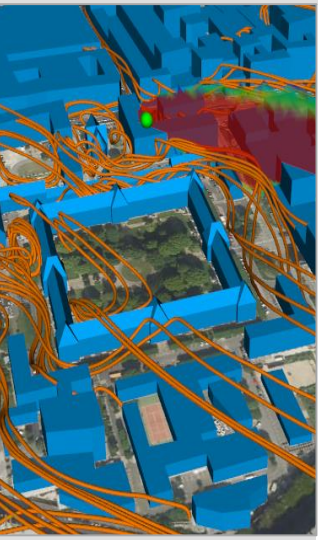
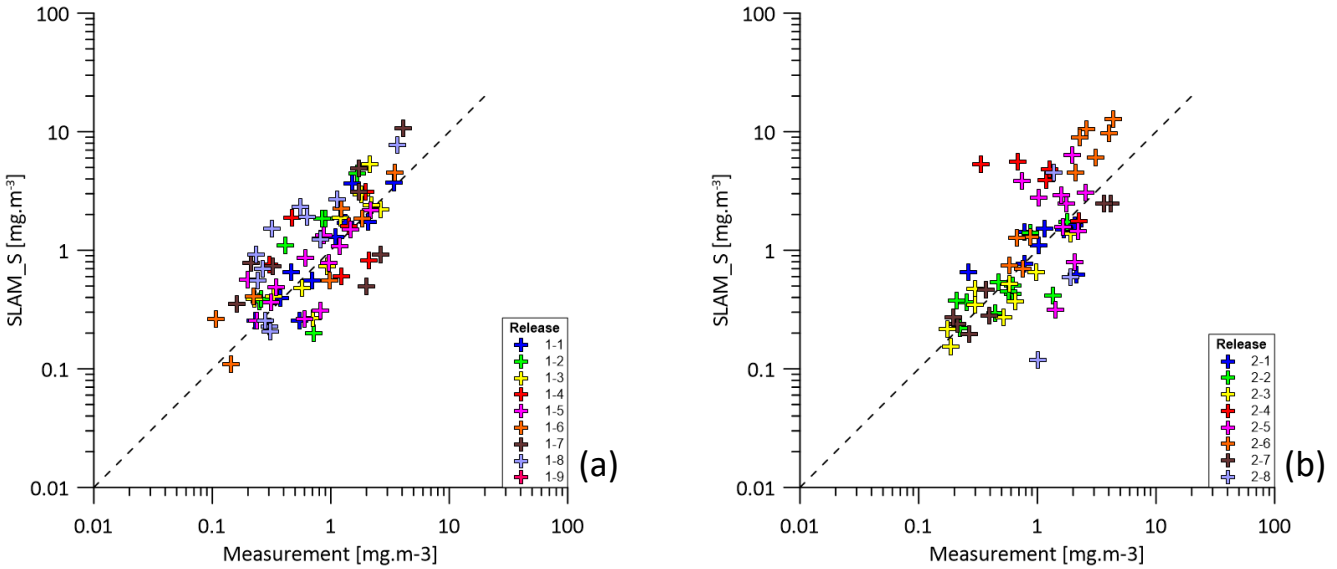
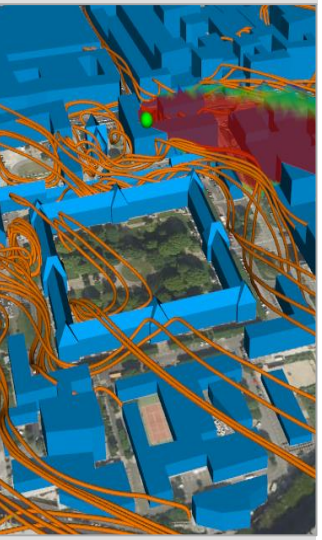




*Comparison of concentrations measured and modelled with SLAM_S, using meteorological data provided by **LIDAR**, for campaign 1 (a) and campaign 2 (b)*

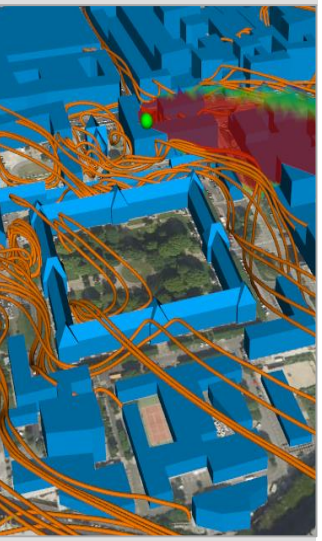
CONCLUSIONS

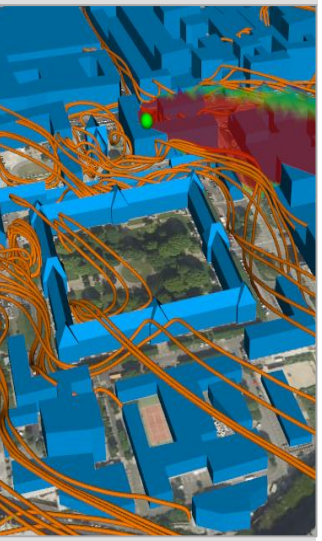
- Results show a **good correlation between SLAM_S estimates and measurements**
- Results are globally more satisfactory using meteorological data from the wind LIDAR
- This highlights the **sensibility of the modelled concentrations to meteorological input**. Further analysis will be carried out to explain the results discrepancies between the different campaigns and the different releases



ACKNOWLEDGMENTS

The authors thank the IRSN, Fluidyn France SARL and the LMFA of the Ecole Centrale de Lyon for the co-financing of the DIFLU project (IRSN collaboration agreement n° 21607), and the company Advanced Accelerator Applications for the authorization to deploy equipment and carry out measurements on the Beuvry cyclotron site





THANK YOU !
ANY QUESTIONS ?

http://air.ec-lyon.fr

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