GIROSCOPE – Modelling approaches for atmospheric transport of radionuclides from NNR technologies

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and on behalf of GIROSCOPE WP3 participants

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PIANOFORTE
EUROPEAN PARTNERSHIP FOR RADIATION PROTECTION RESEARCH
GIROSCOPE

NERIS Workshop 2026, 28-30 April 2026, ASNR, Fontenay-aux-Roses, France

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Aim and objectives

- Aim: To achieve an atmospheric transport and dispersion modelling framework – including models and data – suitable for (a) Emergency Preparedness and Response (EP&R) to potential accidents in Novel Nuclear Reactors (NNRs) types studied in the project; (b) Environmental Impact Assessment (EIA) during normal operation of NNRs studied in the project
- Objectives
  - Definition of modelling requirements and identification of potentially existing gaps
  - Identification of suitable modelling approaches and potential development of novel ones
  - Benchmarking against available experimental data
  - Simulations of radionuclides dispersion and deposition resulting from accident scenarios
  - EIA for discharges under normal operation and comparison of new and existing modelling approaches, where applicable

Special emphasis / novel elements

- Particularities of the NNRs siting: proximity to urban or industrial sites, therefore need for small scale computational domain with detailed topography and geometry
- Dispersion modelling of particular radio-nuclides from NNR accident scenarios and routine operation discharges
- Use and benchmarking of atmospheric dispersion modelling approaches suitable for the particular project requirements
- Multiple accident scenarios, multiple siting cases, multiple modelling systems

Completed activities

- Review and identification of new modelling and data requirements
  - *Report on new modelling requirements*, GIROSCOPE-D3.1 [D9.182] finalised and available at https://pianoforte-partnership.eu/web_object/d9182_modellingrequirements_giroscope.pdf
  - Compilation of information on atmospheric models / modelling systems to be employed by the GIROSCOPE partners (model types, spatial and temporal scales, nuclides, I/O requirements, etc.)

Ongoing activities

- Atmospheric dispersion computational simulations for accident conditions
  - Model validation with experimental data is underway: 2 field experiments made available by the partners
  - “DIFLU” project experiment, made available by ASNR
    - Beuvry cyclotron, located in a peri-urban area / tracer gas (He) releases from the facility / concentration measurements, meteorological measurements / site buildings geometry data available by ASNR and processed by NCBJ and CIEMAT / wider area buildings and terrain data produced by NCBJ / case suitable for dispersion model validation in near field and complicated geometry
  - Suffield experiment, made available by CNL
    - Radiological Dispersal Device experiment / radioactive substance (La-140) dispersion and deposition after explosion/ concentration, deposition, dose rate measurements / case suitable for validation of radionuclide dispersion – deposition – dose rate models

DIFLU experiments simulations by NCBJ: preliminary results

- Workflow:
  - 3D wind data from ERA5 imported into QUIC modelling system
  - Wind field was reproduced by QUIC over computational domain through interpolation and empirical relations
  - Dispersion of He simulated by Lagrangian particle model

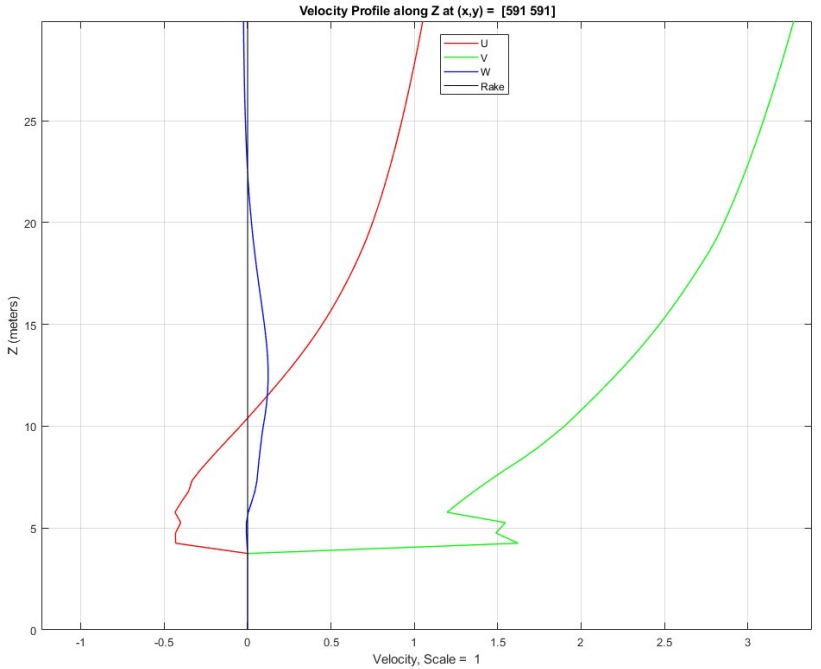

Fig. 1 Example of wind profile close to cyclotron obtained from running QUIC with 3D EPA5 wind data

DIFLU experiments simulations by NCBJ: preliminary results

- Domain and example of results
  - Domain size and height to be established; preliminary runs suggest top height < 200 m
  - Trees and high bushes modelled as vegetation zones with specified attenuation coefficient
  - Elevation data included due to its influence on surface roughness and consequently wind

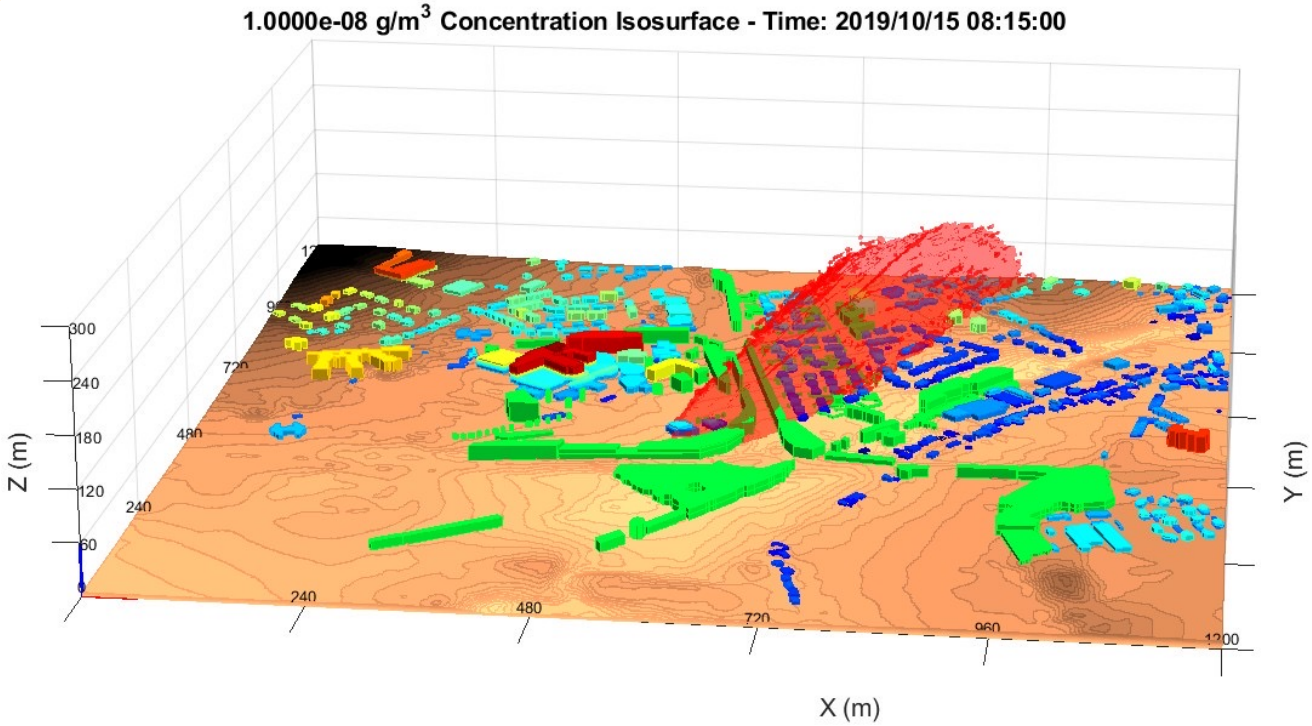

Fig. 2 Example of 3D helium plume visualisation after 15 minutes. Green - vegetation zones; buildings colored by height

DIFLU experiments simulations by NCBJ: preliminary results

- Remarks
  - Too fast plume travel (due to lower surface roughness from ERA5 than for the target 1.2 km domain)
  - No variability of wind speed or of angle included resulting in almost flat concentration profile
- Following steps to improve results
  - Downscaling of ERA5 data to finer resolution through mesoscale model (e.g., WRF)
  - Inclusion / assimilation of anemometer measurements
- Model performance metrics:
  - Mean concentration, peak concentration, plume arrival time, statistical indices over all measurement locations, etc.

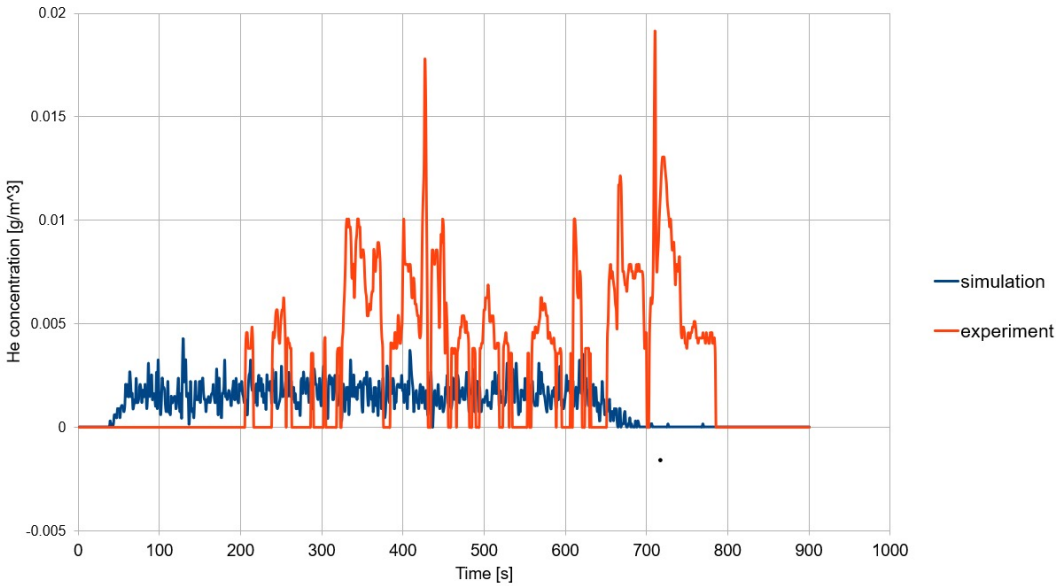

Fig. 3 He concentration for 1-1 DIFLU simulation vs. experiment

Ongoing activities

- Simulations of radiological consequences from NNR accident scenarios – accidental and normal operation source terms and NNR sites are defined in other parts of the project
  I. One NNR accident source term is applied on location and weather conditions of the experimental case (DIFLU experiment) by all partners (with each partner's selected modelling system)
  II. NNR accidents source terms will be applied on NNR locations and weather conditions according to available siting data, to each partner interests and available resources
  III. Normal operations NNR source terms will be applied through suitable methodologies for EIA / possibly new models and/or methods will be compared to existing modelling techniques

  Results from (I) and (II) will be applied in other parts of the project to draw recommendations on protective actions
- NCBJ site buildings and terrain data have been made available for simulations corresponding to NNR siting in a complex industrial area

On going activities

- Where necessary: modelling systems extensions will be carried out / suitable modelling frameworks will be set up / novel modelling approaches will be considered, based on
  - conclusions from the previously mentioned finalized review report
  - challenges encountered as the computational simulations evolve
- All mentioned activities will lead to corresponding deliverable reports, publicly available on the PIANOFORTE web site

Thank you very much for your attention!

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