Atmospheric dispersion modelling in the European Weather Cloud

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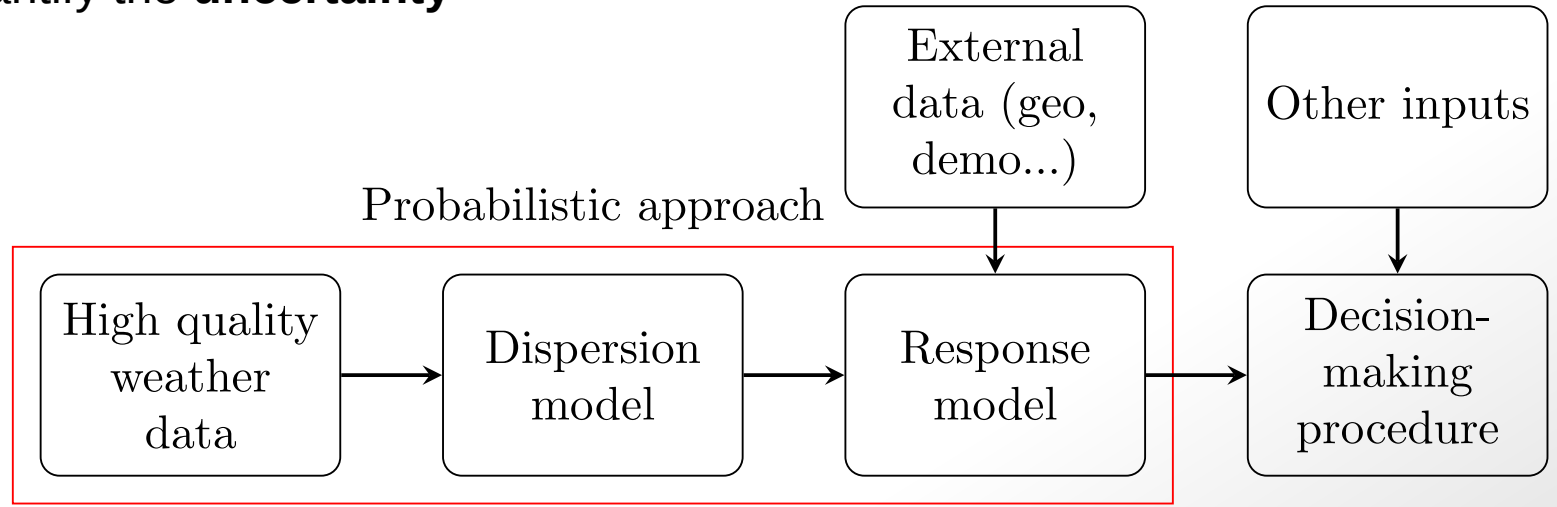
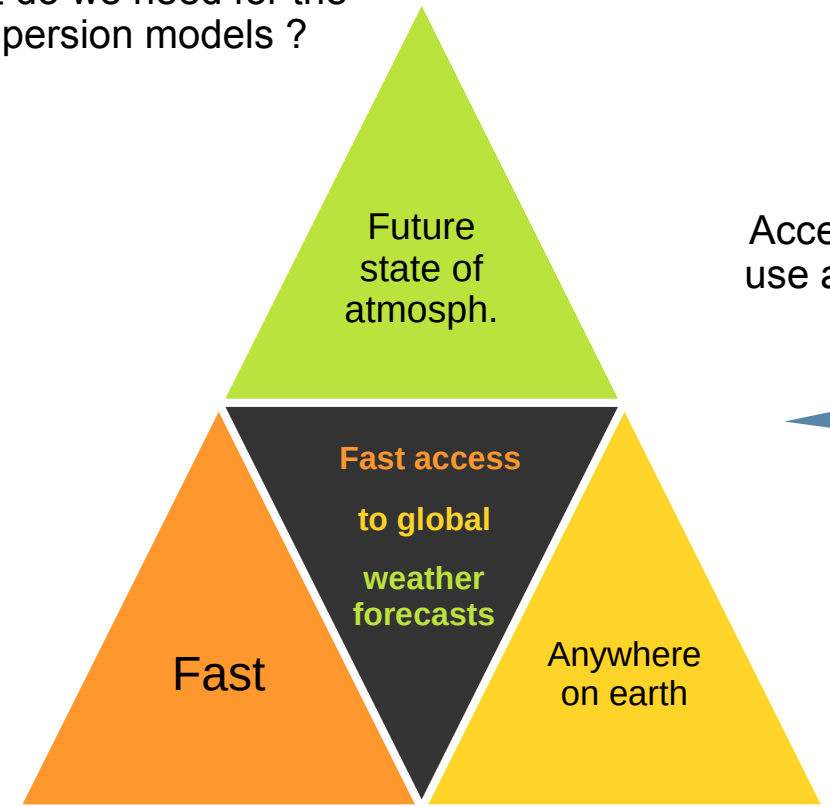
Context

- Improve **decision-making** in case of **CBRN incidents** (Chemical, Biological, Radiological, Nuclear)
- **Atmospheric dispersion models** can predict hazardous species concentration
- **Event-based simulation** to couple concentration predictions with population density, topography etc.
- Quantify the **uncertainty**



Requirements and goals

What do we need for the dispersion models ?



Accessible, easy to use and to visualize

Web-application on the European Weather Cloud, using ECMWF forecasts

Web app - Technical discussion

Backend



Modern scientific computing language

Performance, composability, clearness

Easy to install on the cloud

Frontend



Good tooling and integrated best practices (opinionated framework)

Good scaling

API

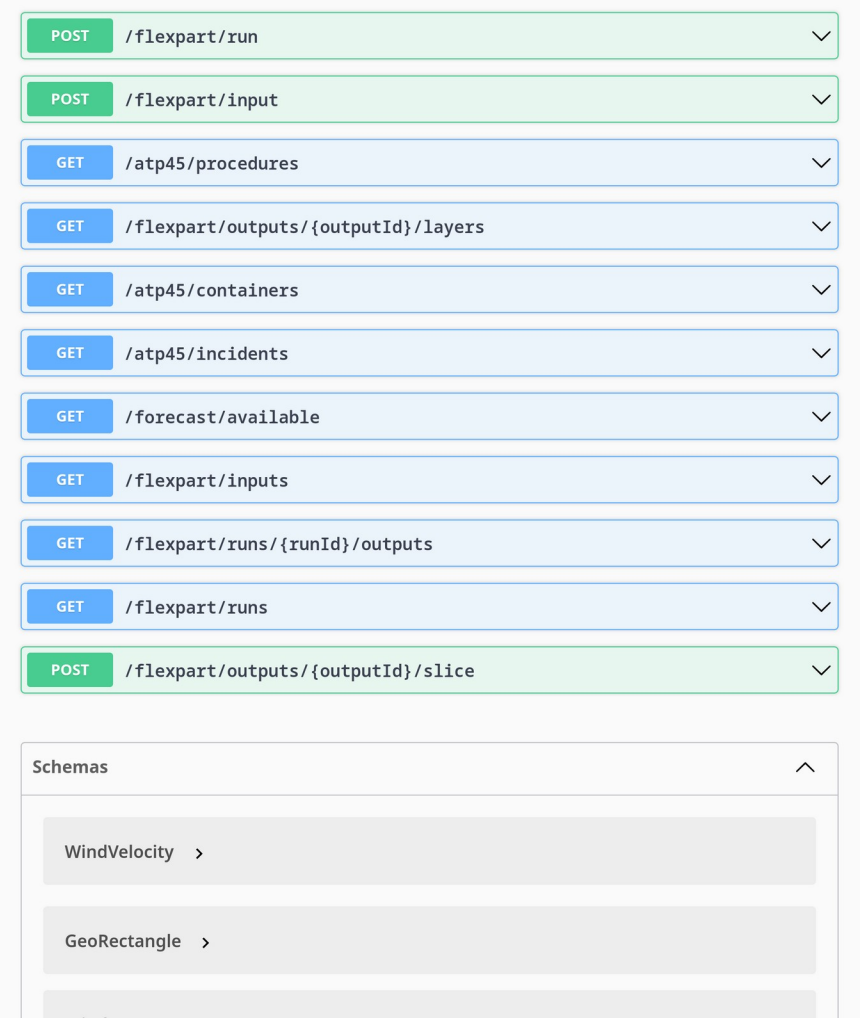


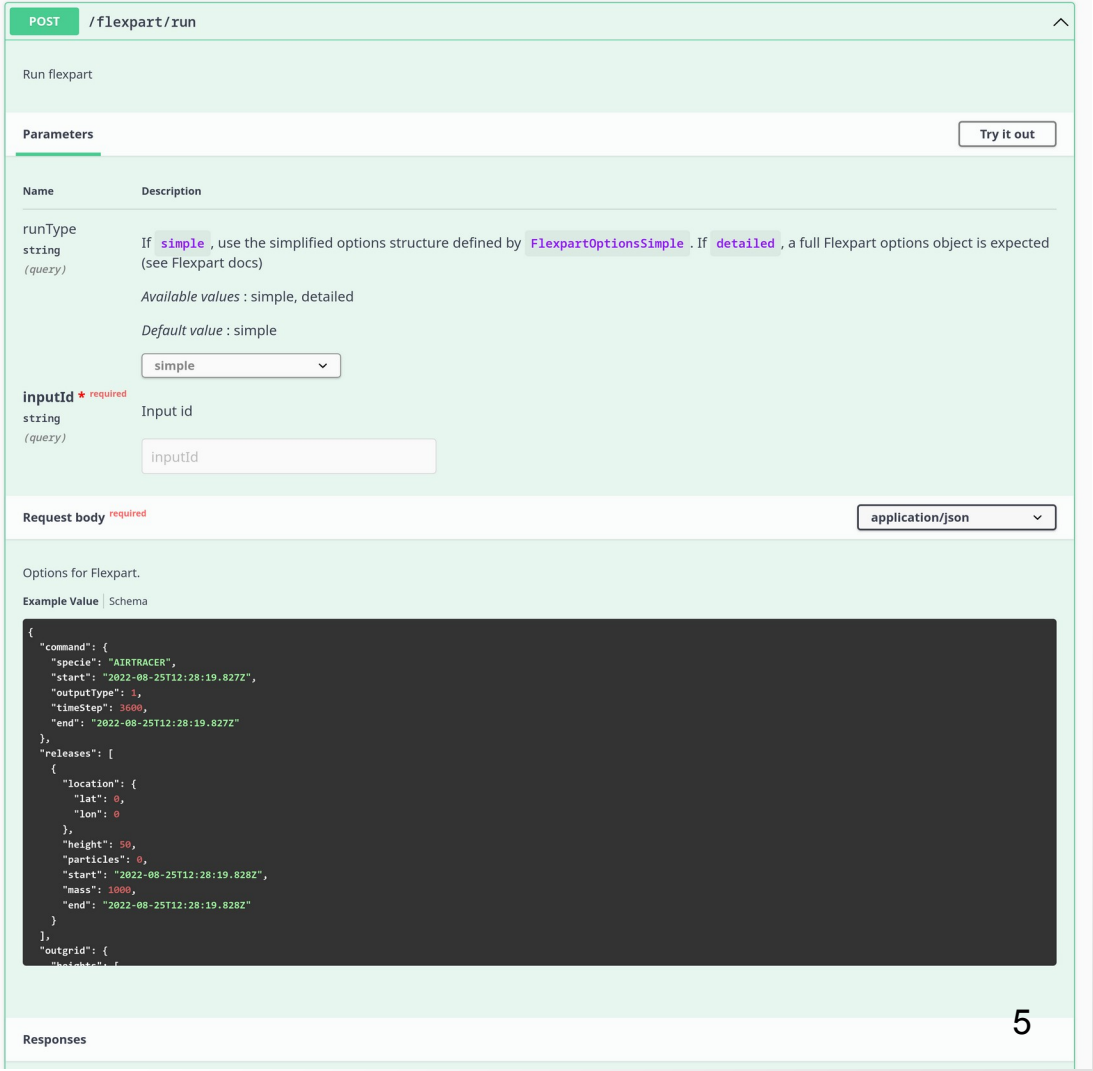
REST API

Backend decoupled from GUI

Organized and extensible backend

OpenAPI – documentation example





Application features

Running dispersion models

- ✓ NATO ATP45
- ✓ FLEXPART
- ✗ Gaussian plume
- ✗ Gaussian puffs
- ✗ ...

Uncertainty quantification

- ✓ Deterministic
- ✗ Ensemble
- ✗ Sensitivity
- ✗ Monte Carlo

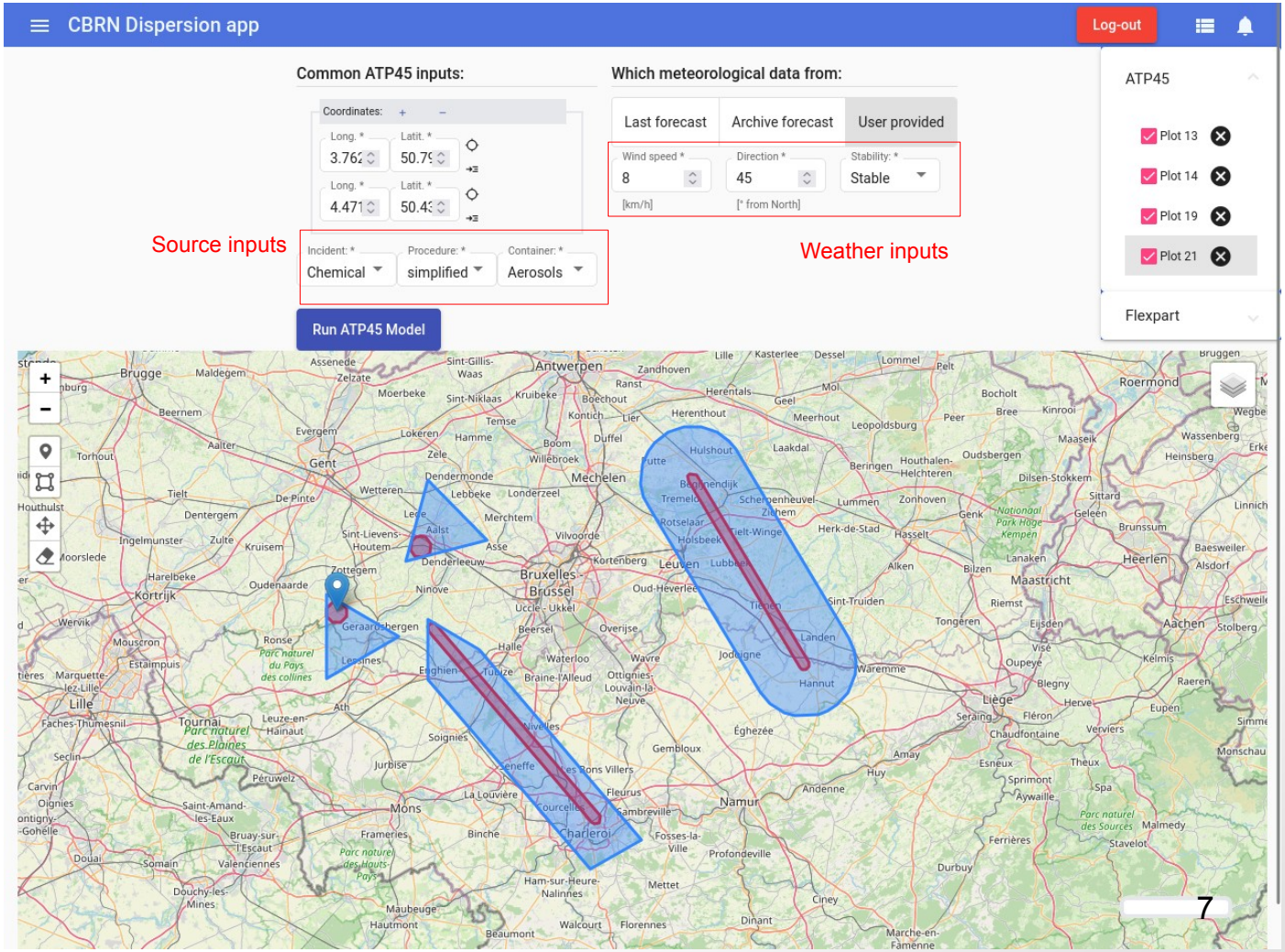
- ✗ Event-based simulation

Visualization

- ✓ Interactive plots
- ✗ Detailed plots

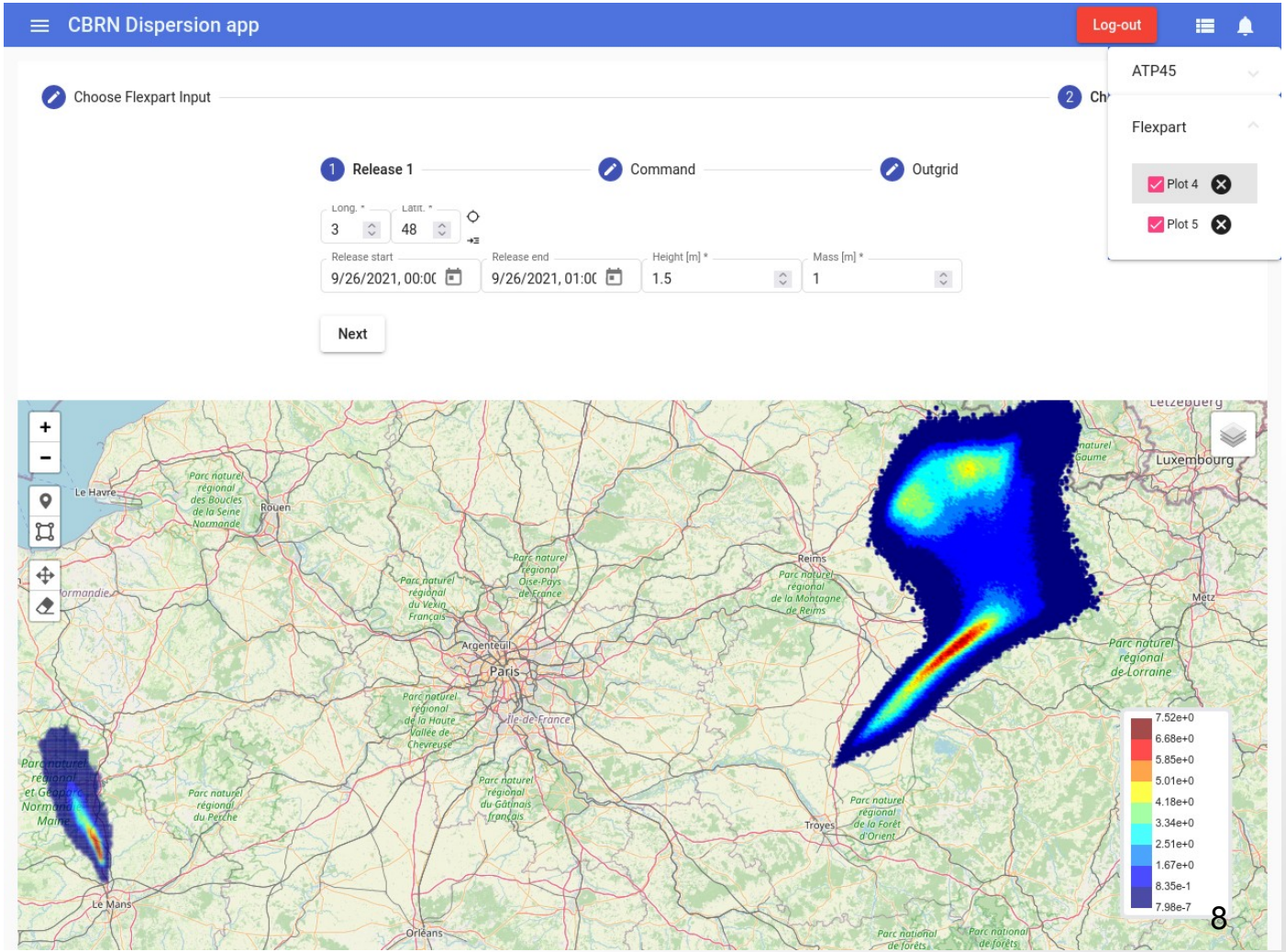
Web app - ATP45

- Very simple model based on a NATO procedure
- Specific for CBRN-type incidents
- Atmosphere: only wind and stability
- Source: type of incident, type of container
- Output: geospatial shapes for hazard area



Web app - FLEXPART

- Lagrangian dispersion model
- Atmosphere: substantial amount of meteorological data
- Source: species quantities, chemical properties, height…
- Output: Geospatial distribution of the specie concentration



Some discussion about uncertainty

Uncertainty analysis

- Inputs: use of ensemble forecasts.
- Parameters: run the model with parameters as probability distributions

Sensitivity analysis

- Parameters: calculation of the partial derivatives of the model equations w.r.t some parameters
- Can be made analytically or numerically (automatic differentiation)

Final remarks

Multiple Julia package developed:

- **Flexpart.jl**: a Julia interface to FLEXPART
- **EcRequests.jl**: call to the ECMWF web API in Julia
- **GRIBDatasets.jl**: high level interface to GRIB files
- **ATP45.jl**: run the NATO models
- **GaussianDispersion.jl**: run Gaussian plume and puff models