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SIMPAX: A Prototype Software Application Simulating the Impact of Radioxenon Emissions from Civil Sources on IMS Stations

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Introduction

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) established a global monitoring system for atmospheric xenon radioactivity as part of the International Monitoring System (IMS).

During the International Noble Gas Experiment (INGE), a significant correlation between radioxenon background and geographical region was observed. Investigations on the radioxenon background have highlighted that different nuclear civil applications were contributing to this background.

The major contributors to this background are a few Medical Isotope Production Facilities dispersed all around the world; other smaller contributors are Nuclear Power Plants and Hospitals. The radioxenon background makes the discrimination between radioxenon detections from civil nuclear applications and from nuclear testing a very complex task.

The scientific challenge is to develop algorithms and tools that facilitate the understanding of the background. The longer-term vision is to eventually predict the impact of civil sources on the radioxenon detections at the IMS stations.

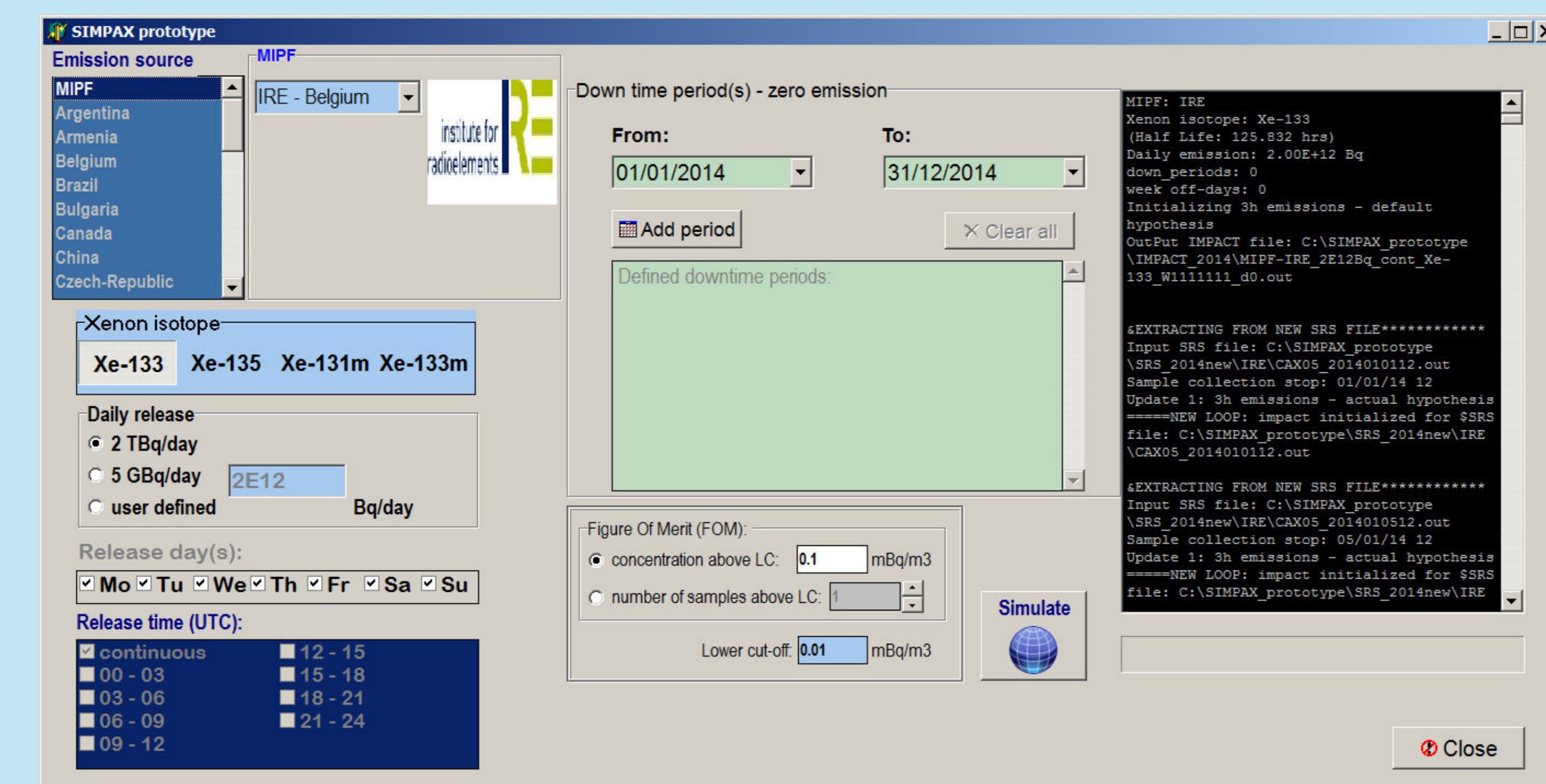
With the goal of gaining first experience and scientific insight, a prototype software application is developed at the International Data Centre (IDC) to calculate hypothetical radioxenon concentrations at IMS stations, based on a combination of source-receptor sensitivity (SRS) fields and estimated civil radioxenon releases. The software tool is baptized SIMPAX – Prototype (Simulated IMPAct of Xenon).

The contribution aims at presenting the key features of SIMPAX prototype in terms of simulation model, input definition and output format.

Release scenario

The following source term parameters can be defined via the GUI:

- Emission source selection from a list of identified Medical Isotope Production Facilities (MIPF) and Nuclear Power Plants (NPP).
- Selection of xenon isotope among the four that are relevant to CTBT verification;
- Week-day released activity (Bq/day);
- Release days can be selected (by means of check boxes);
- Currently, only continuous emission mode is available;
- Any down-time period(s) over the simulation time frame can be defined.



Adding a new emission source to SIMPAX configuration requires corresponding SRS fields to be extracted using a dedicated script:

```
4.7M Feb 2 2014 SEX63.fp.2014020112.f9.srm.gz
5.1M Feb 2 2014 SEX63.fp.2014020100.f9.srm.gz
```

```
#!/bin/bash
MATCH="50.00 5.00"
NAME="IRE"
OUTDIR=/dv/scratch/RN/Christophe/IRE_2014
for j in $(seq -w 1 12)
do
#extract for the whole year 2014
SRCDIR=/ops/products/atm/srs/2014/$(j)/flexpart.x.ecmf.l1
#extract for one month 01
SRCDIR=/ops/products/atm/srs/2014/01/$(j)/flexpart.x.ecmf.l1
for i in $(SRCDIR)/*gz
do
values=$(gunzip -c $(i) | egrep "$MATCH")
if [ -n "$values" ]; then
STA=$(basename $(i) | cut -d "." -f 1)
MWD=$(basename $(i) | cut -d "." -f 2)
MWD=$(basename $(i) | cut -d "." -f 3)
OUTFILE=$(STA)_$(MWD).out
echo $(i)
#echo -n "$(NAME) $(STA) $(MATCH)" > $(OUTDIR)/$(OUTFILE)
echo -e "$(NAME) $(STA) $(MATCH)$(source $i) $(gunzip -c $(i) | awk '{print $3}' )" > $(OUTDIR)/$(OUTFILE)
echo $(values) | sed -e 's/0,00 0,00 /nvg/ >> $(OUTDIR)/$(OUTFILE)
fi
done
```

Script input:

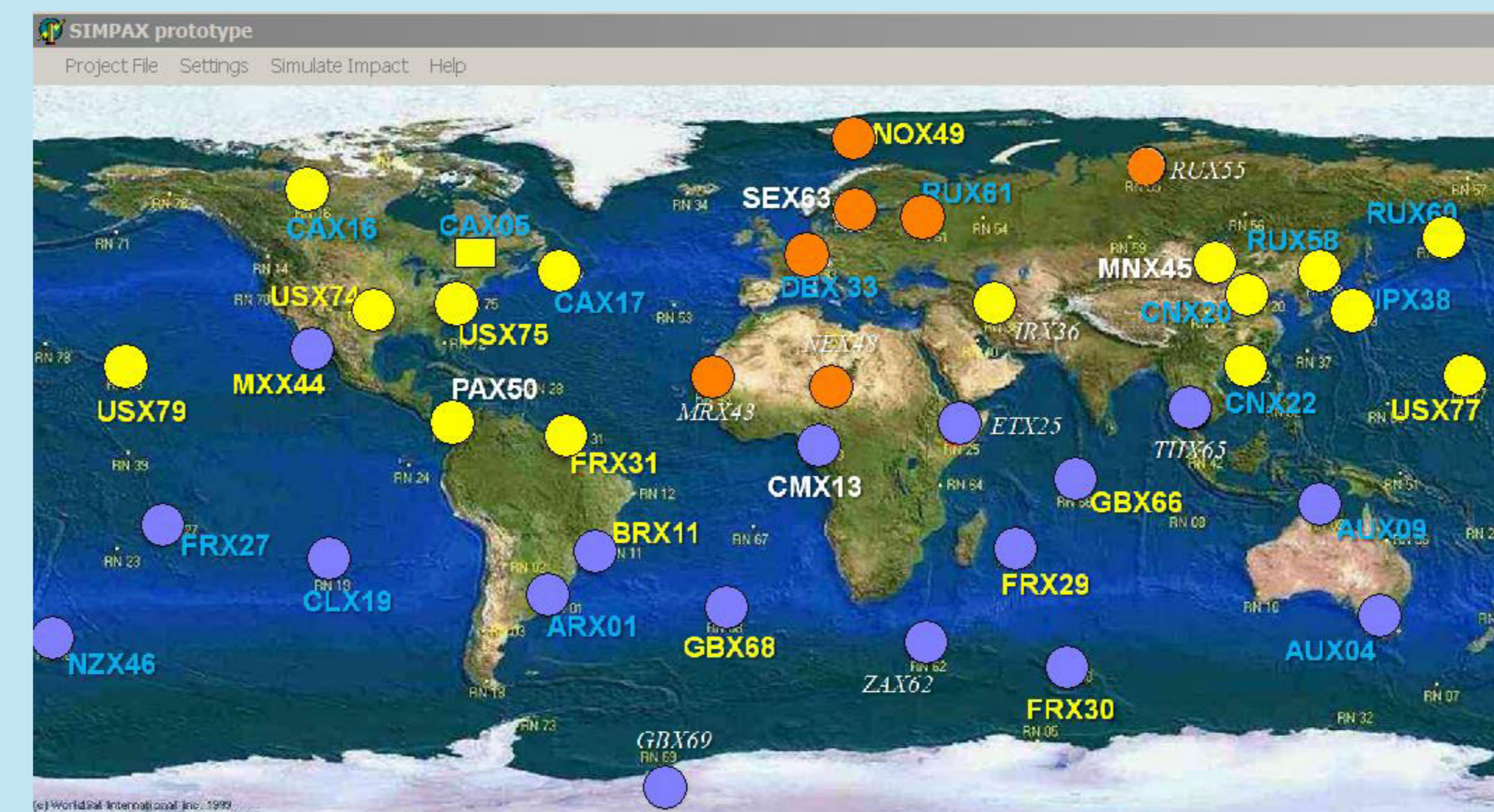
- Contains the geographical location of the emission source (e.g. IRE) for extracting the grid corresponding SRS fields;
- Time frame of interest (e.g. whole year 2014).

The output consists of one SRS field file per emission source, per IMS location and per sample.

Simulation results – a) Overall impact

Simulation results are materialized with contextual color-coded semaphore for each IMS station, depending on the impact level over the simulation period :

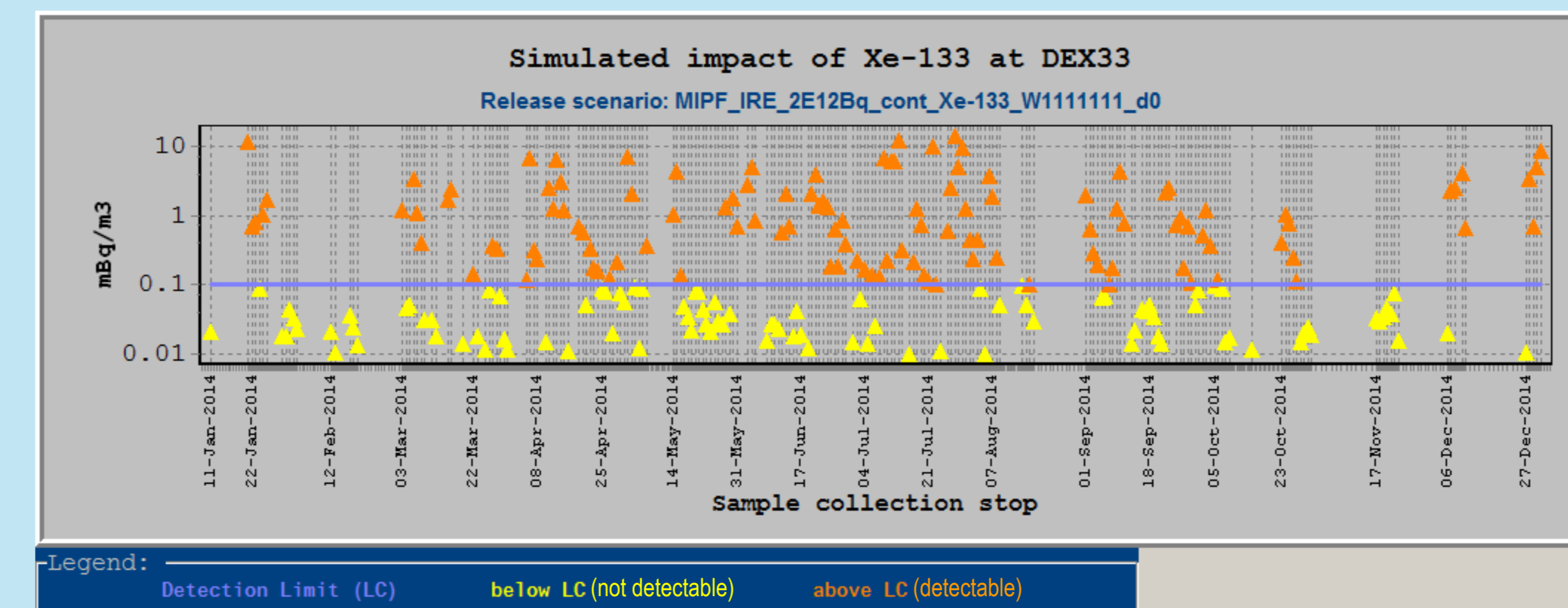
- Orange:** if at least one simulated activity concentration is above LC for the corresponding Noble Gas system;
- Yellow:** if all the simulated activity concentrations are below LC and at least one non-zero value;
- Blue:** if all simulated activity concentrations are equal to zero.



b) Individual stations

By clicking on the semaphore of an impacted IMS station, the following plot is brought up.

The plot shows time series of predicted impact in mBq/m3 taking into account the sampling cycle of the IMS system (12 h for SAUNA and ARIX; 24 h for SPALAX).



Various controls are available in a popup menu for customizing the plot attributes. Numerical results are also available on the GUI and can be exported to ASCII.

```
SUB-RESULTS FOR STATION SPECIFIC IMPACT
- ReleaseScenario: MIPF_IRE_2E12Bq_cont_Xe-133_W1111111_d0
- IMS Noble Gas site: DEX33
```

SOURCE	STATION	DATE	IMPACT (mBq/m3)
MIPF_IRE	DEX33	11/01/2014 06:00:00	2.13E-02
MIPF_IRE	DEX33	21/01/2014 06:00:00	1.13E+01
MIPF_IRE	DEX33	22/01/2014 06:00:00	6.97E-01
MIPF_IRE	DEX33	23/01/2014 06:00:00	8.12E-01
MIPF_IRE	DEX33	24/01/2014 06:00:00	8.62E-02
MIPF_IRE	DEX33	25/01/2014 06:00:00	1.05E+00
MIPF_IRE	DEX33	26/01/2014 06:00:00	1.68E+00
MIPF_IRE	DEX33	30/01/2014 06:00:00	1.85E-02
MIPF_IRE	DEX33	31/01/2014 06:00:00	1.81E-02
MIPF_IRE	DEX33	01/02/2014 06:00:00	4.47E-02
MIPF_IRE	DEX33	02/02/2014 06:00:00	3.34E-02
MIPF_IRE	DEX33	03/02/2014 06:00:00	2.37E-02

Use case

SIMPAX has been used for establishing a baseline of radioxenon activity concentrations at IMS Noble Gas systems over the year 2014 (Gueibe et al., 2017).

Outlook

SIMPAX prototype software application was developed at the CTBTO International Data Centre.

SIMPAX allows users to gain first experience and scientific insight on potential impact of radioxenon emissions from civilian sources on IMS radionuclide station sites, as well as any location for OSI purposes.

Potential use cases include:

- Possible support to radioxenon background campaigns;
- Simulating the background for specific locations;
- Measurement/ validation by noble gas mobile system.

The current prototype can be ported to open source for use by National Data Centres.

SIMPAX can be enhanced by implementing additional functionalities and new features which need expert input, such as:

- New options for source definition: input files based on defined format or local database;
- Automatic combination of simultaneous emission sources for simulating overall impact.
- Storing the output in local database.

References

Gueibe et al., (2017), "Setting the 2014 Baseline for Simulated Activity Concentrations of Four Radioxenon Isotopes at IMS Sites Based on Estimated Annual Releases of Known Sources", SandT2017 Conference, poster T2.4-P11.