DE LA RECHERCHE À L'INDUSTRIE

Simulation of the radioxenon background at the global scale: Implementation of STAX data in the French NDC operational tool

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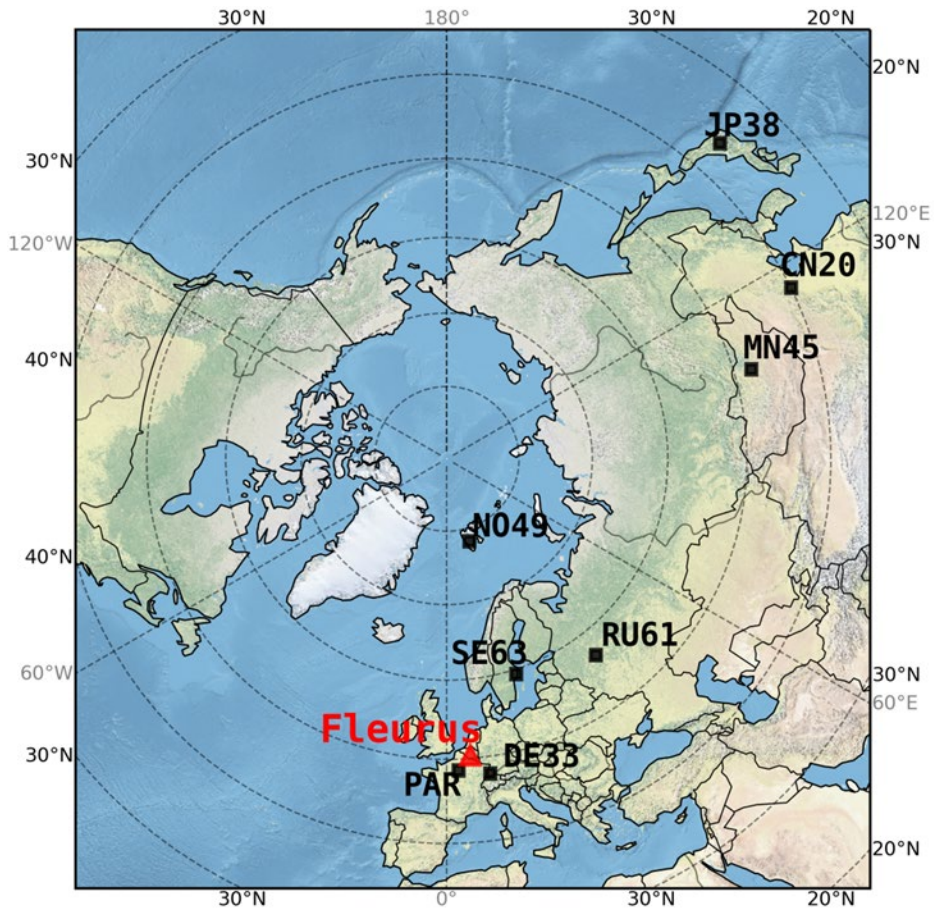
Commissariat à l'énergie atomique et aux énergies alternatives - www.cea.fr

- Summary of the operational simulation of radioxenon background
- Method used for implementing STAX data in automatic simulations (providing past-time and forecast)
- What is the influence of the knowledge of IRE (Fleurus) source term (STAX), compared to a priori, on simulated activity concentrations as a function of the distance to the source ?
  - Analysis of 1-year **simulation** time series at station locations
  - First lessons learned from comparison to measurements

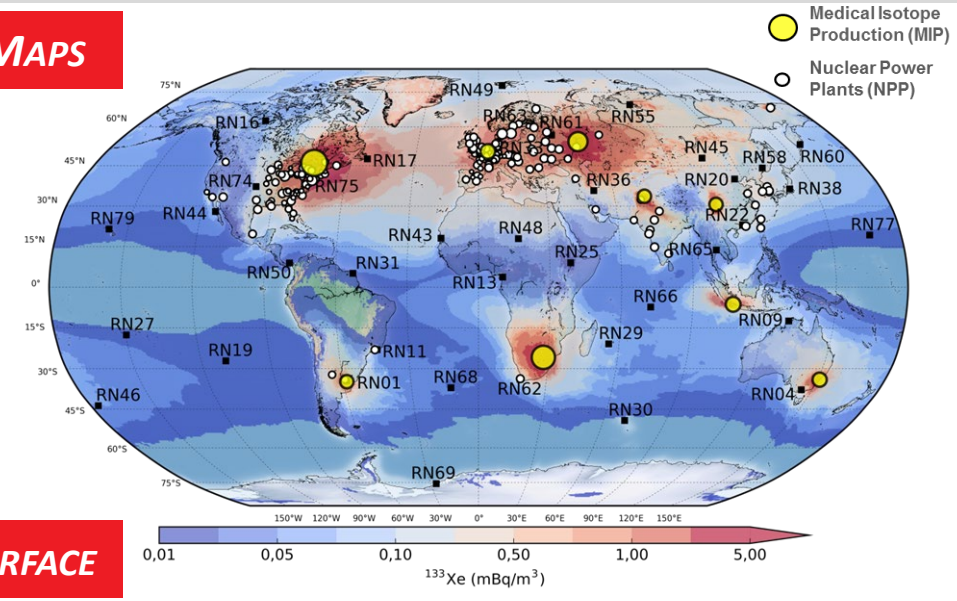


Operational simulation of the ^{133}Xe background

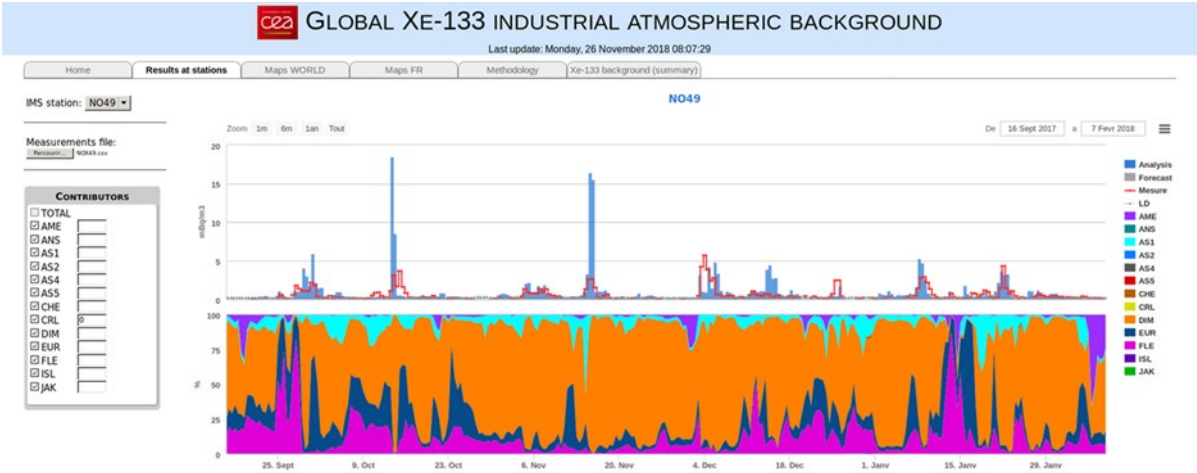
- **Automatic simulations** and processing for the assessment of **^{133}Xe levels at every IMS stations** & **global maps**
- Real time & 4-day forecasts
- GFS **0.5°x0.5°** / output 0.5°x0.5°
- Taking into account **worldwide releases** of the past 30 days
- > 500 simulations per day (~22 hours per cycle)
- **FORWARD** simulations from sources **A PRIORI inventory**

➢ Used daily by NDC analysts to flag out detections of interest (not “industrial releases as usual”)

GLOBAL MAPS



USER INTERFACE



➢ **New : Addition of IRE (Fleurus) monitored releases from STAX data (PNNL/IRE)**

ACHIM ET AL. 2016, *Journal of Geophysical Atmospheres*
GENEROSO ET AL. 2018, *Journal of Geophysical Atmospheres*

Implementation of the STAX data in the automatic simulations

- Release information required as input of the ATM simulations (FLEXPART) :

```
*******************************************************************************
*                                                                             *
*   Input file for the Lagrangian particle dispersion model FLEXPART          *
*                        Please select your options                           *
*                                                                             *
*   KIND of trajectory: 1 = 3-dimensional                                     *
*                       2 = 2-dimensional (terrain-following)                 *
*                                                                             *
*                                                                             *
*******************************************************************************
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 1
 21
===============================================================================
20210429 000000
20210429 001500
 4.5354
 50.4504
 4.5354
 50.4504
      1
   20.000
   40.000
   46875
5.18e+09
FLE
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
20210429 001500
20210429 003000

                                    ...

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
20210429 021500
20210429 023000
```

1st 15-min time slot

Nb of lagrangian particles (Total per day = 4,5 millions)

Release in Bq/15 min from STAX

2nd 15-min time slot

96th 15-min time slot

- Ensure daily reliable provision of RELEASE files from D-30 -> D+4, each including 96 15-min releases data

(500 simulations / 22 hours calculation cycle depend on it)

ROUTINELY ON **D DAY** :

Automatic download of D-1 data (.csv)
At 02 TU https://stax.isti.com
(Shell script provided by ISTI)

ARCHIVED → STAX database

Creation of input files for FLEXPART

Calculation of 15-min average releases depending on week days
From [Aug 18 – Jan 20 data]

ALL 96 DATA AVAILABLE

AT LEAST 1 DATA MISSING

Releases D-1
- 96 15-min release data from **STAX**

ARCHIVED

Releases D-1
- Missing 15-min releases replaced by **STAX averages**

ARCHIVED

Releases D to D+4
- 96 15-min release data from **STAX averages**

NOT ARCHIVED

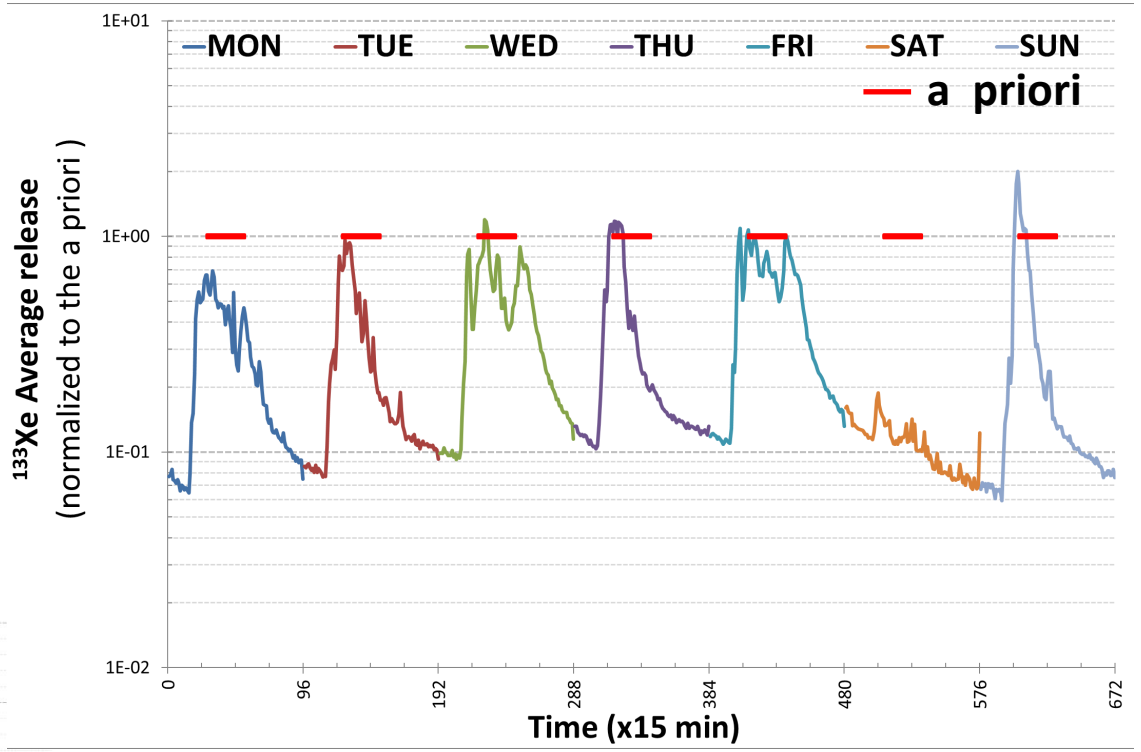
Since May 15, 2020 and as of May 14, 2021 :
365 files created, including 20 with missing data
(either partially or fully missing, either due to missing data or errors in the creation of RELEASE files for FLEXPART model)

Emission datasets used for ATM simulations

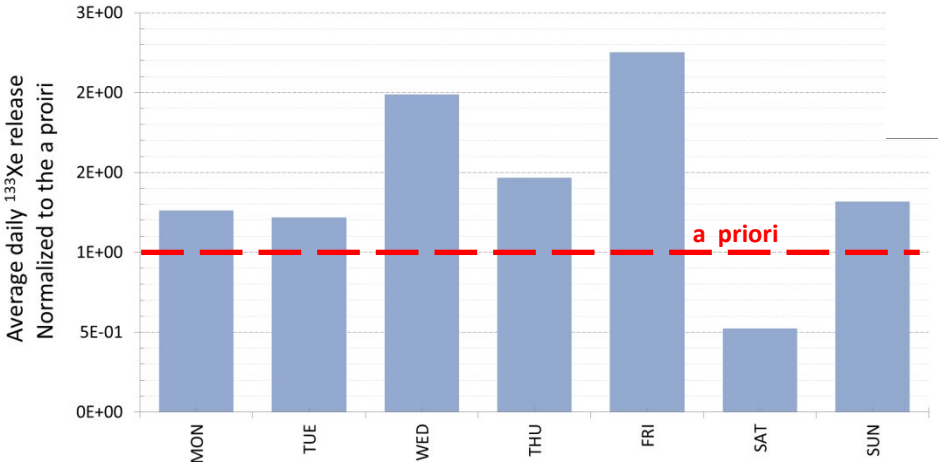
Simulations carried out with 3 different IRE release datasets:

- **A priori** releases (uniform between 05:00-07:00 TU)
- **STAX data** (15-min resolution)
- **STAX average** (averaged 15-min depending on week days)

« **STAX average** » : Averaged 15-min release per week days from STAX (IRE)



Data per 15 min

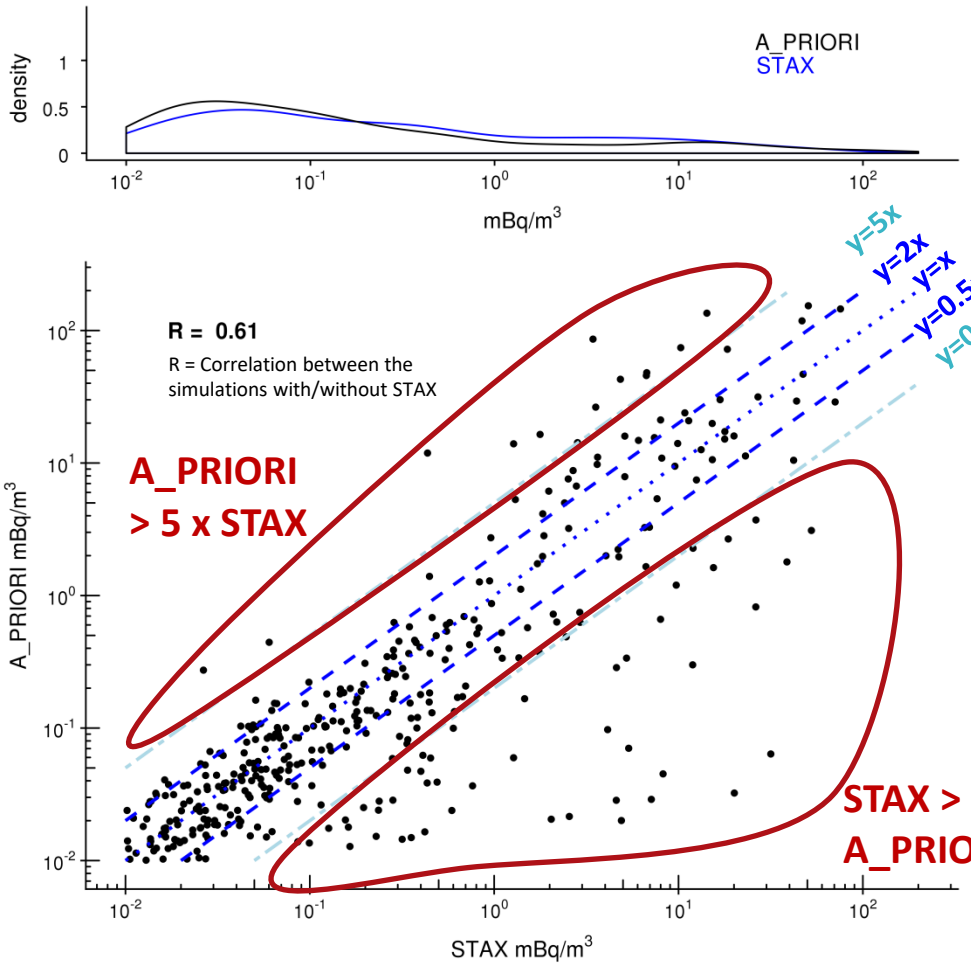


Total per day

« A priori » versus « STAX » (simulations versus simulations)

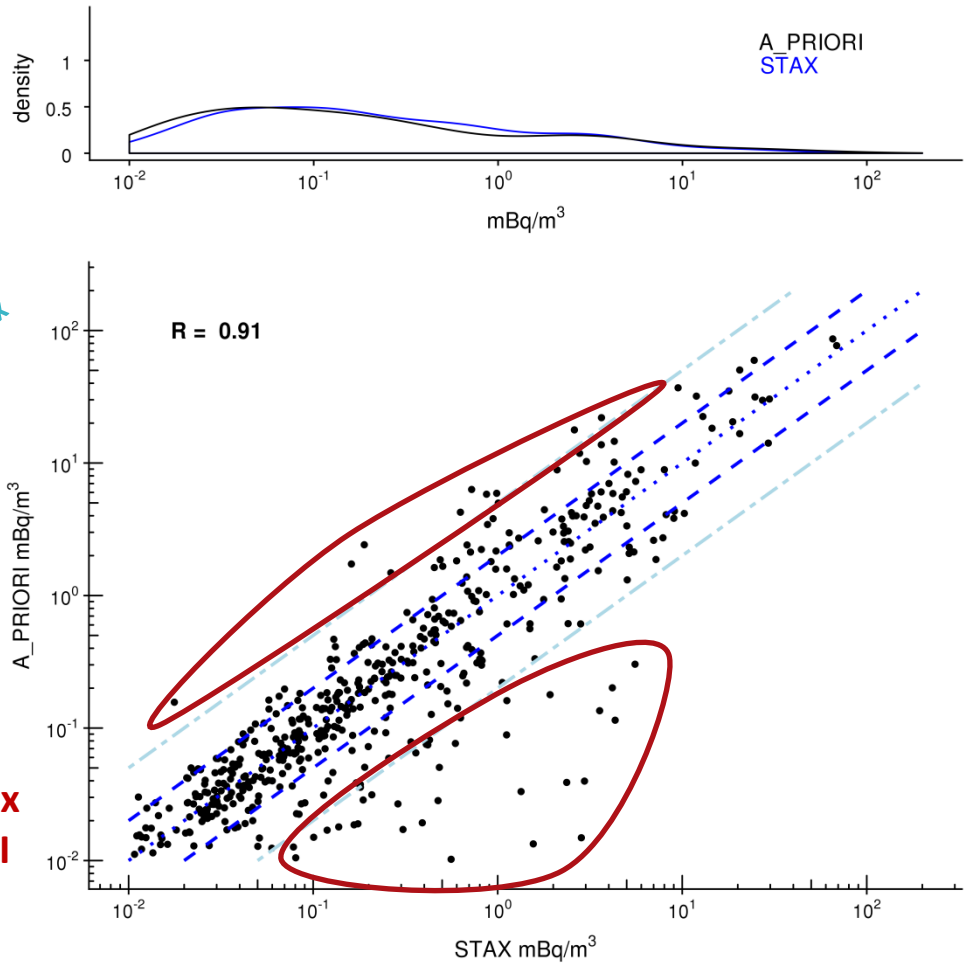
JUNE 2020-APRIL 2021

PARIS – 250 km from Fleurus



One dot = 12h-average activity concentrations simulated at Paris with IRE *a priori/stax* releases (Total of 648 points)

DE33 – 400 km from Fleurus

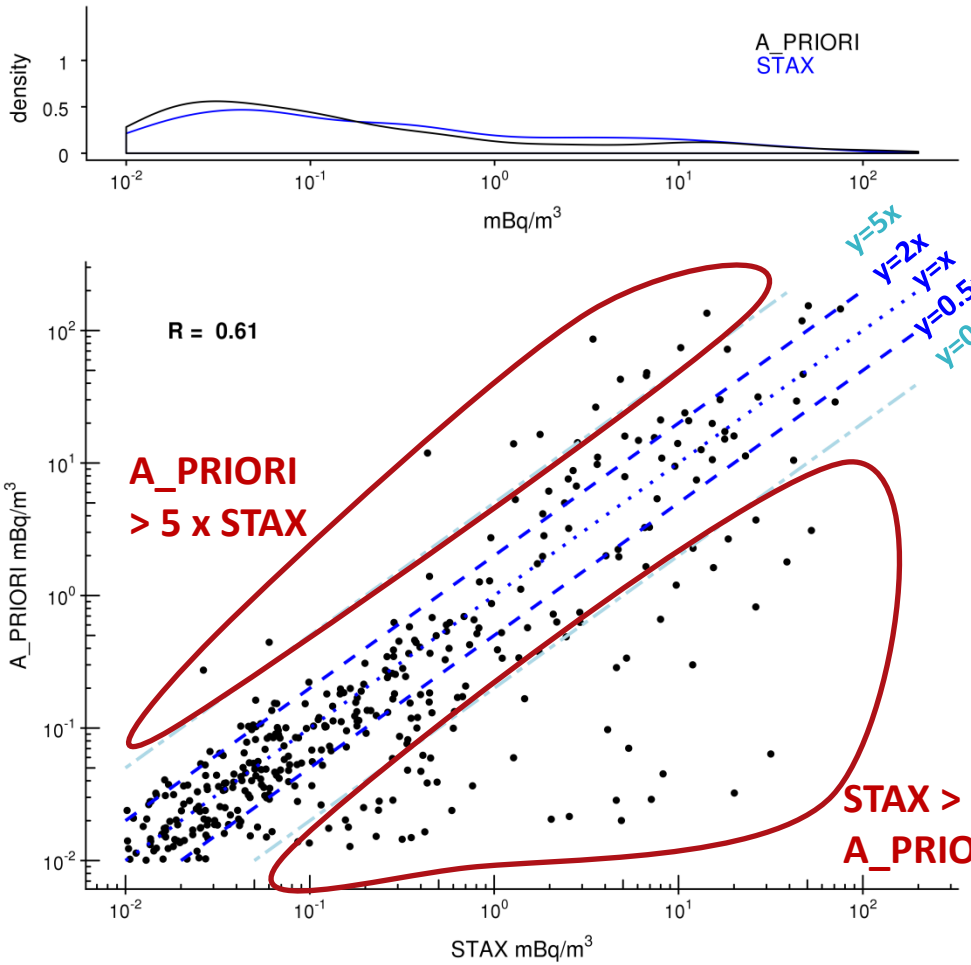


Same at DE33 (Freiburg, Germany)

« A priori » versus « STAX » (simulations versus simulations)

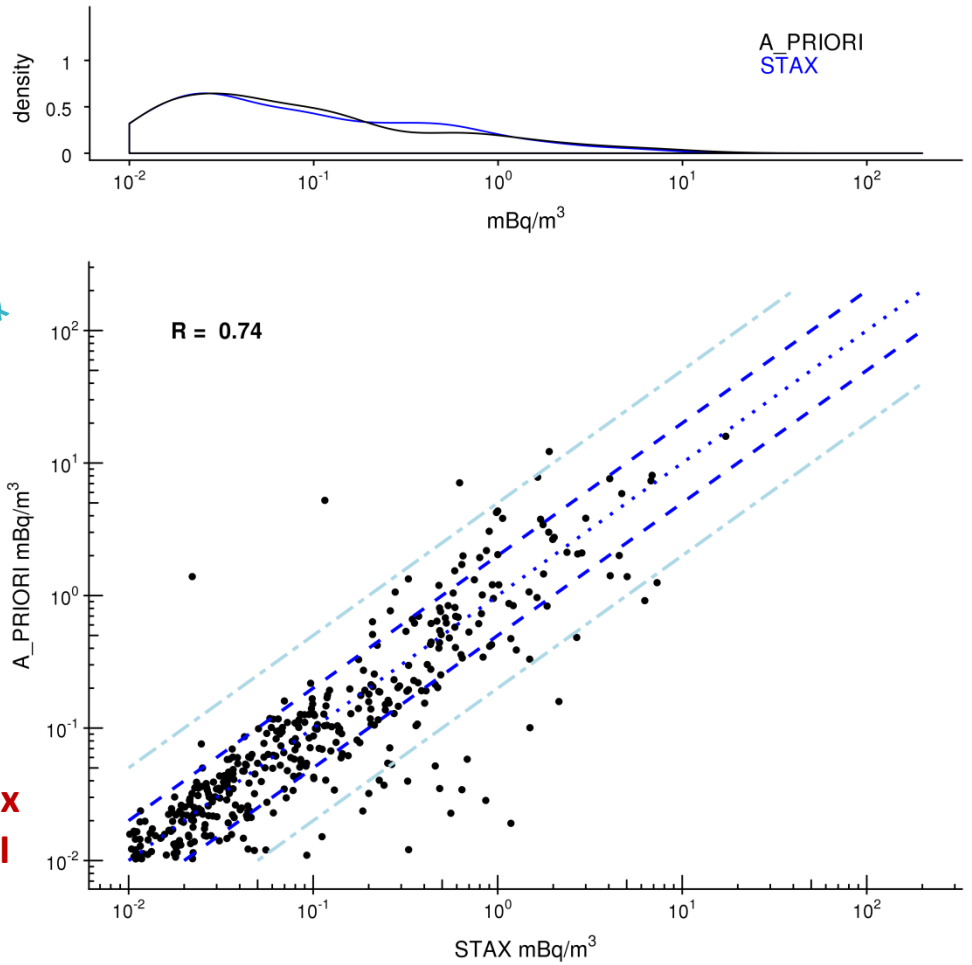
JUNE 2020-APRIL 2021

PARIS – 250 km from Fleurus



One dot = 12h-average activity concentrations simulated at Paris with IRE *a priori/stax* releases (Total of 648 points)

SE63 – 1300 km from Fleurus

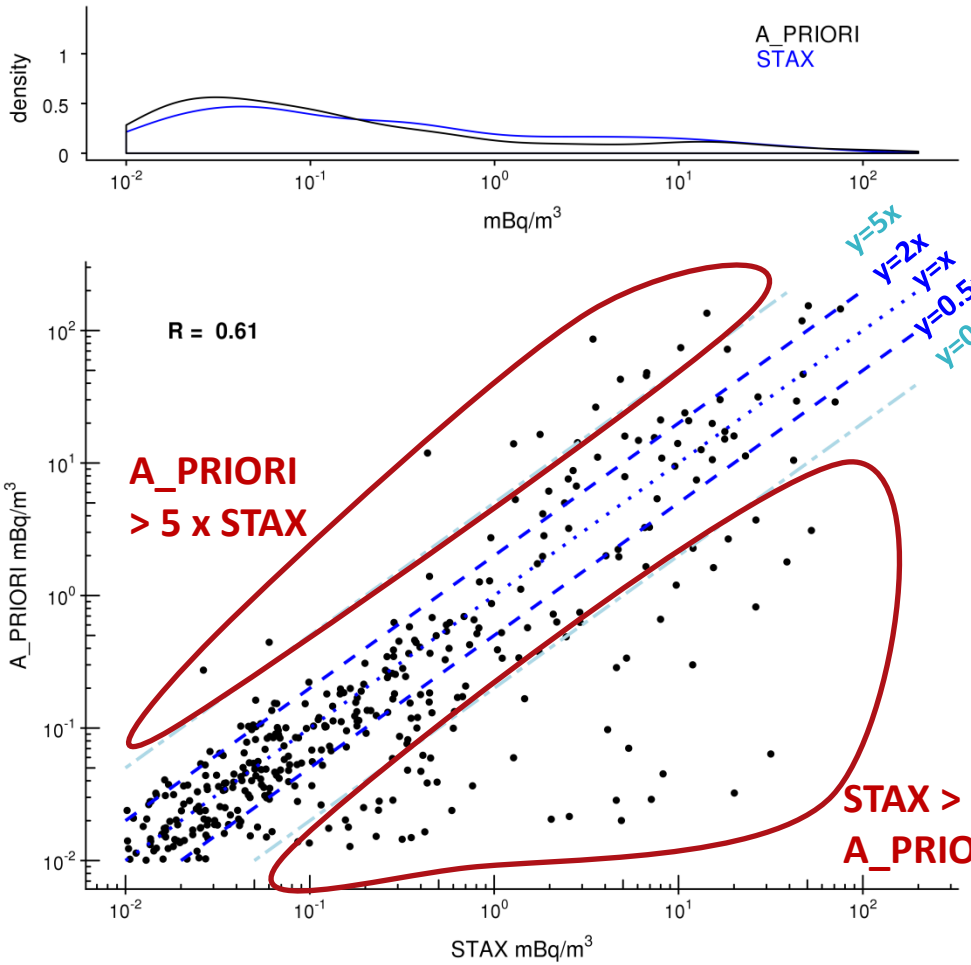


Same at SE63 (Stockholm, Sweden)

« A priori » versus « STAX » (simulations versus simulations)

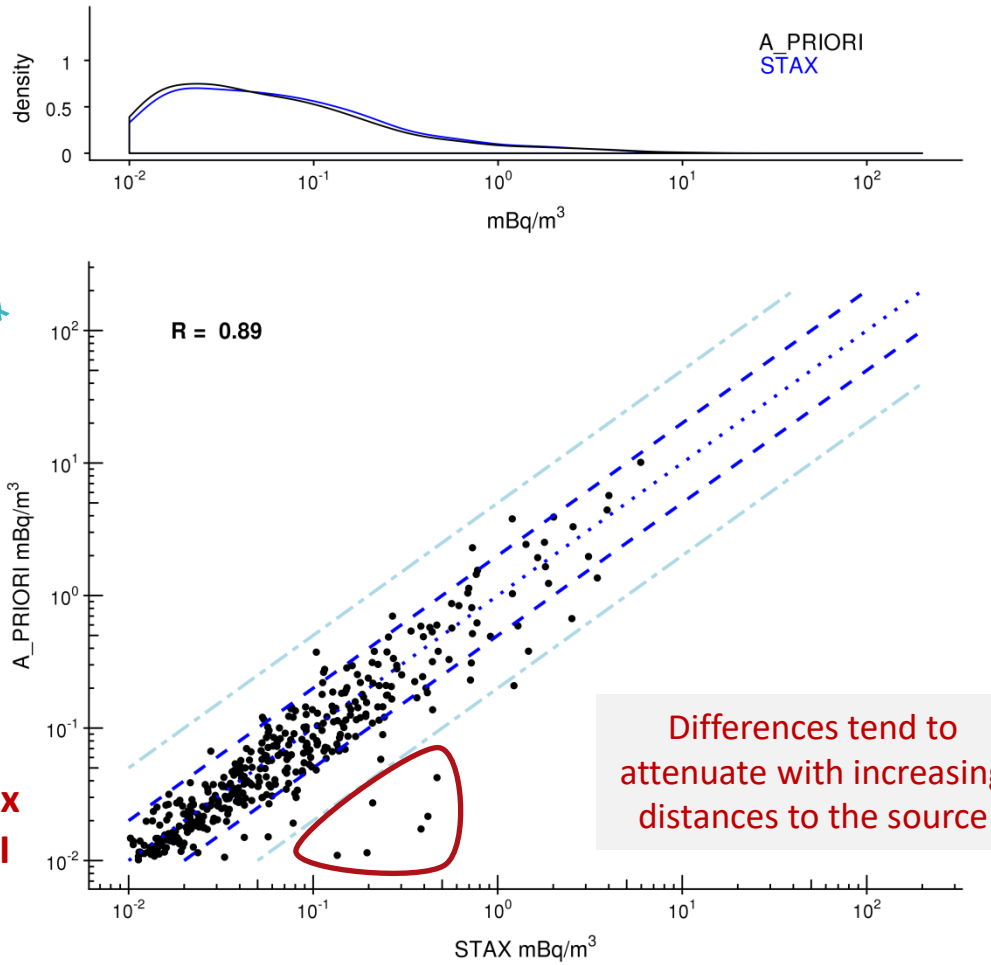
JUNE 2020-APRIL 2021

PARIS – 250 km from Fleurus



One dot = 12h-average activity concentrations simulated at Paris with IRE *a priori/stax* releases (Total of 648 points)

RU61 – 2250 km from Fleurus



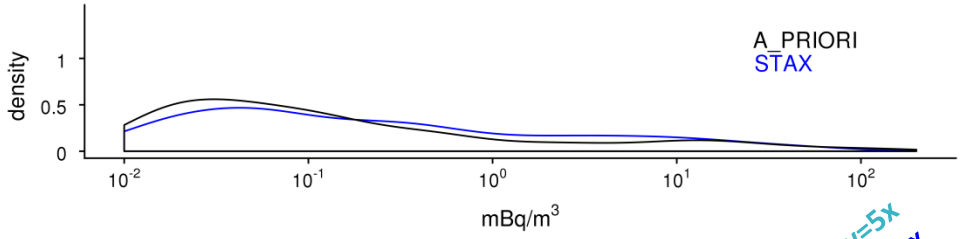
Differences tend to attenuate with increasing distances to the source

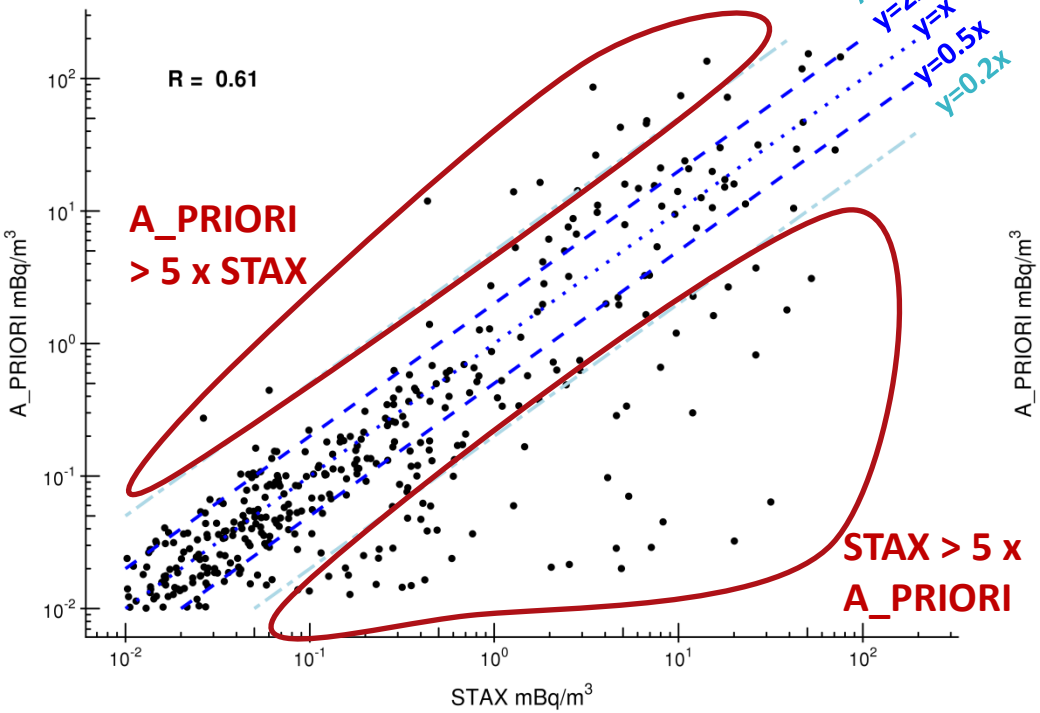
Same at RU61 (Dubna, Russia)

« A priori » versus « STAX » (simulations versus simulations)

JUNE 2020-APRIL 2021

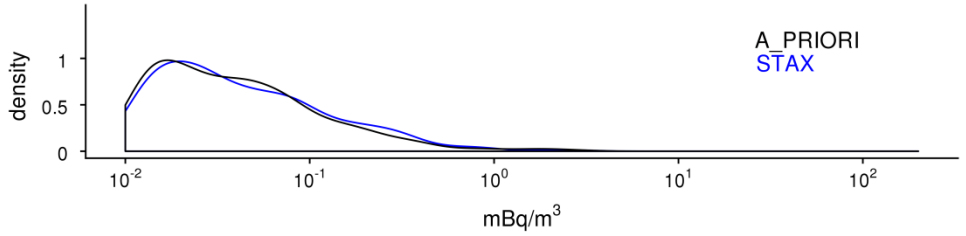
PARIS – 250 km from Fleurus

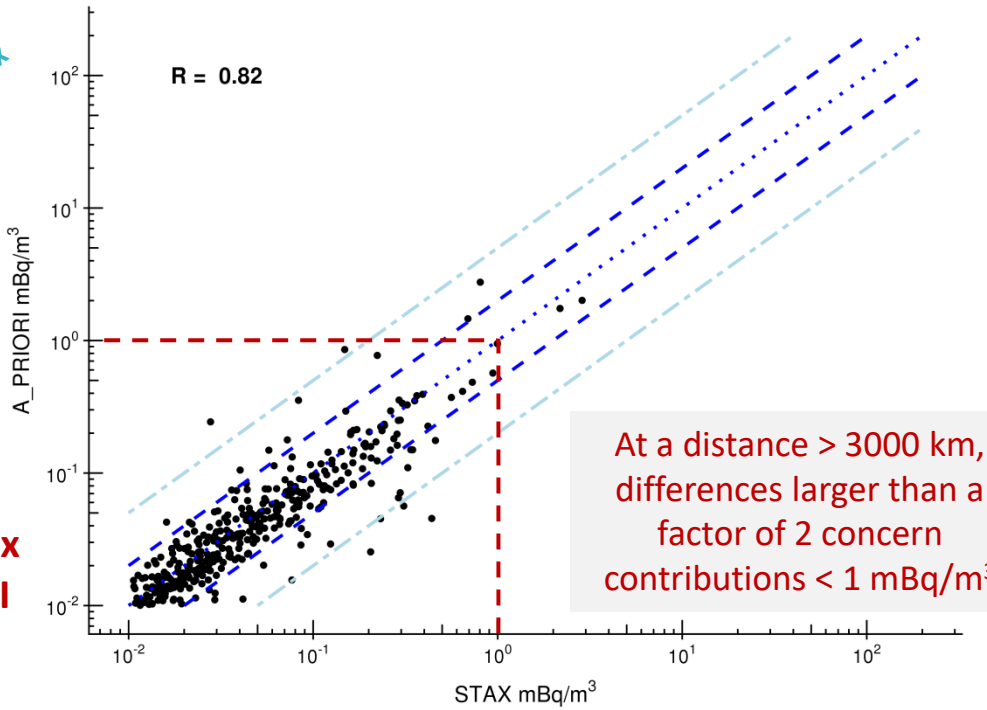




One dot = 12h-average activity concentrations simulated at Paris with IRE *a priori/stax* releases (Total of 648 points)

NO49 – 3100 km from Fleurus





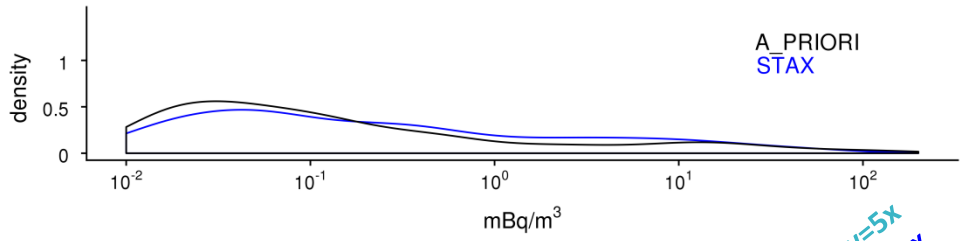
At a distance > 3000 km, differences larger than a factor of 2 concern contributions < 1 mBq/m^3

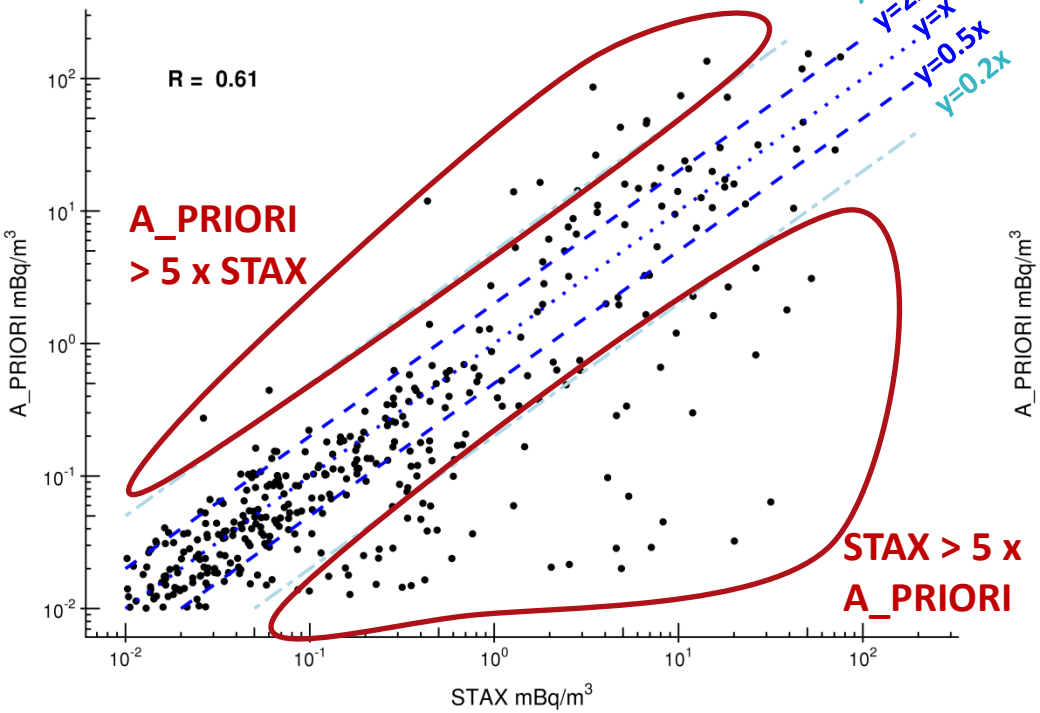
Same at NO49 (Spitsbergen, Norway)

« A priori » versus « STAX » (simulations versus simulations)

JUNE 2020-APRIL 2021

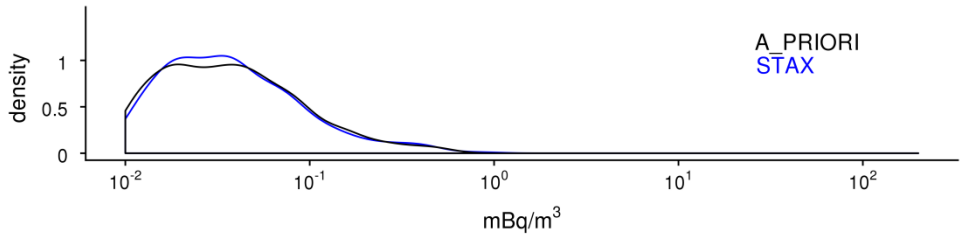
PARIS – 250 km from Fleurus

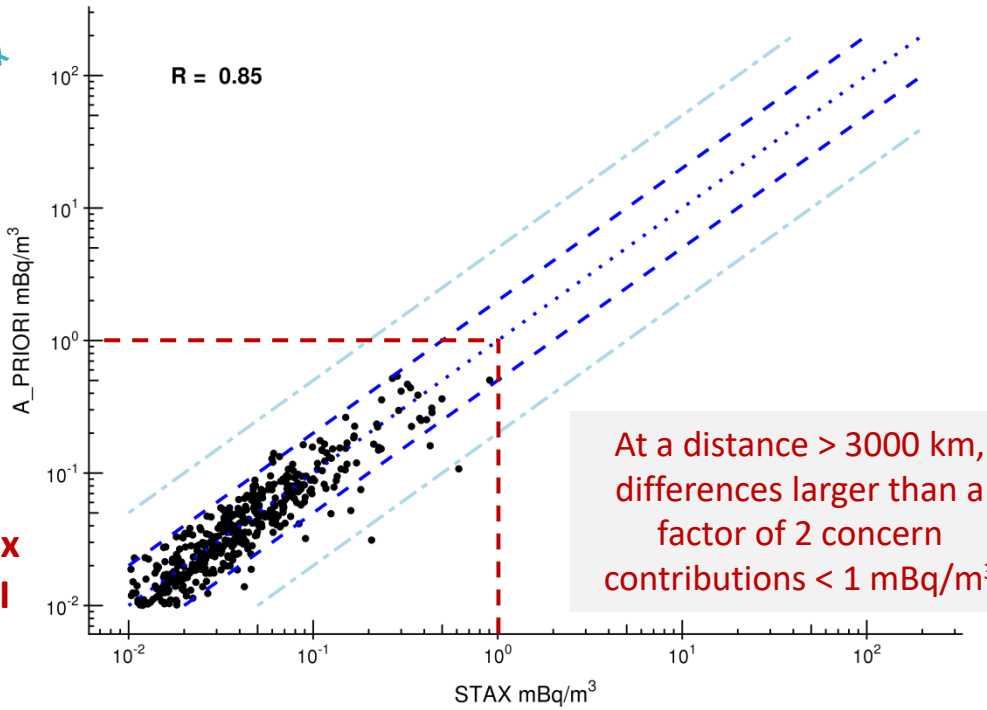




One dot = 12h-average activity concentrations simulated at Paris with IRE *a priori/stax* releases (Total of 648 points)

MN45 – 7000 km from Fleurus





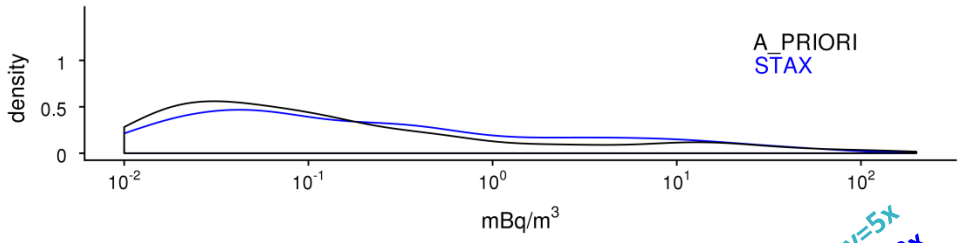
At a distance > 3000 km, differences larger than a factor of 2 concern contributions < 1 mBq/m^3

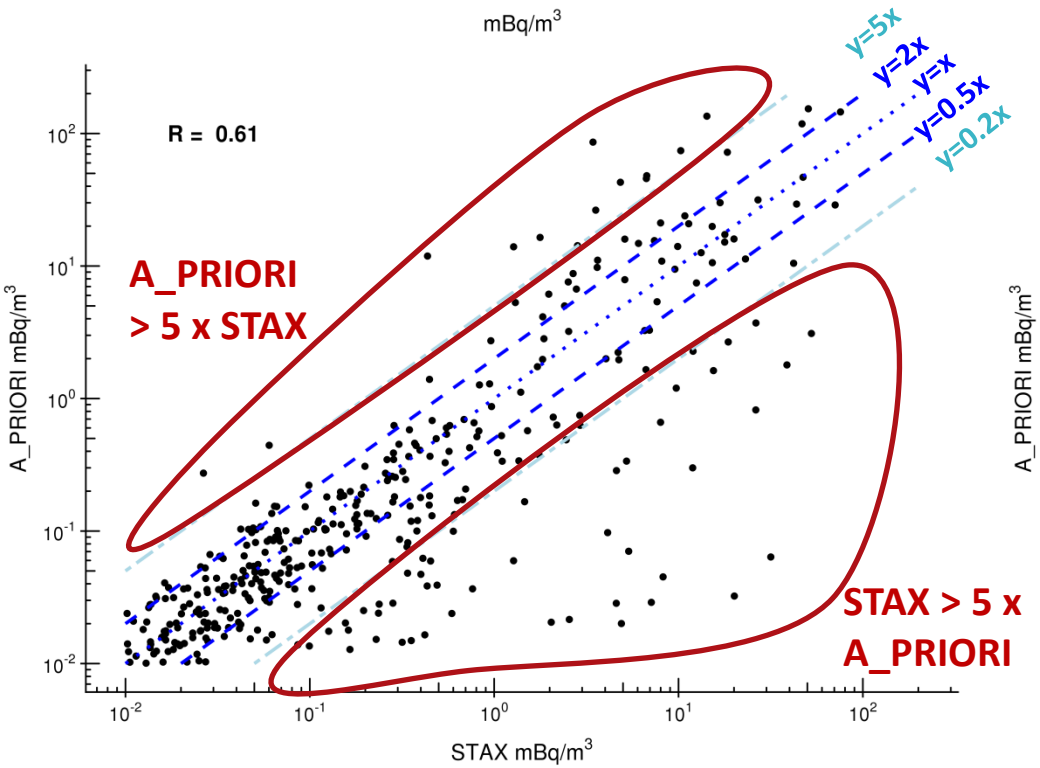
Same at MN45 (Ulaanbaatar, Mongolia)

« A priori » versus « STAX » (simulations versus simulations)

JUNE 2020-APRIL 2021

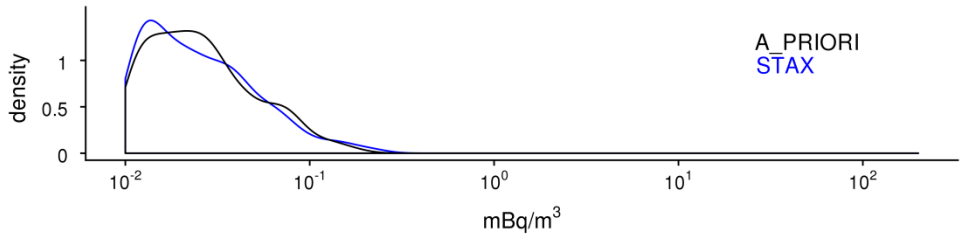
PARIS – 250 km from Fleurus

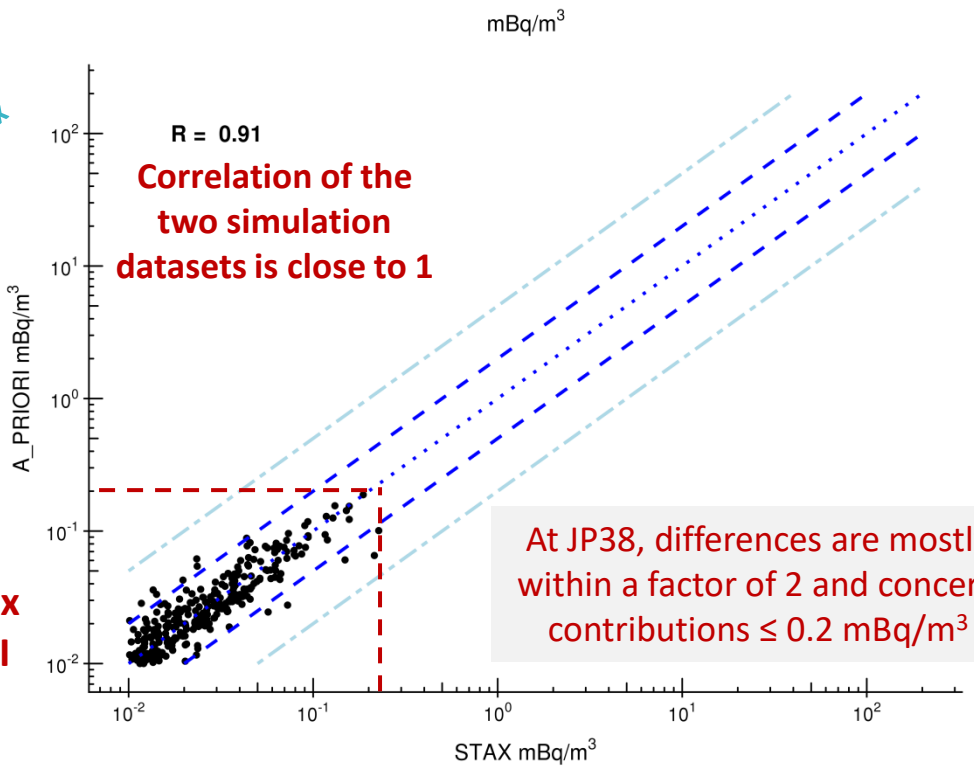




One dot = 12h-average activity concentrations simulated at Paris with IRE *a priori/stax* releases (Total of 648 points)

JP38 – 9000 km from Fleurus



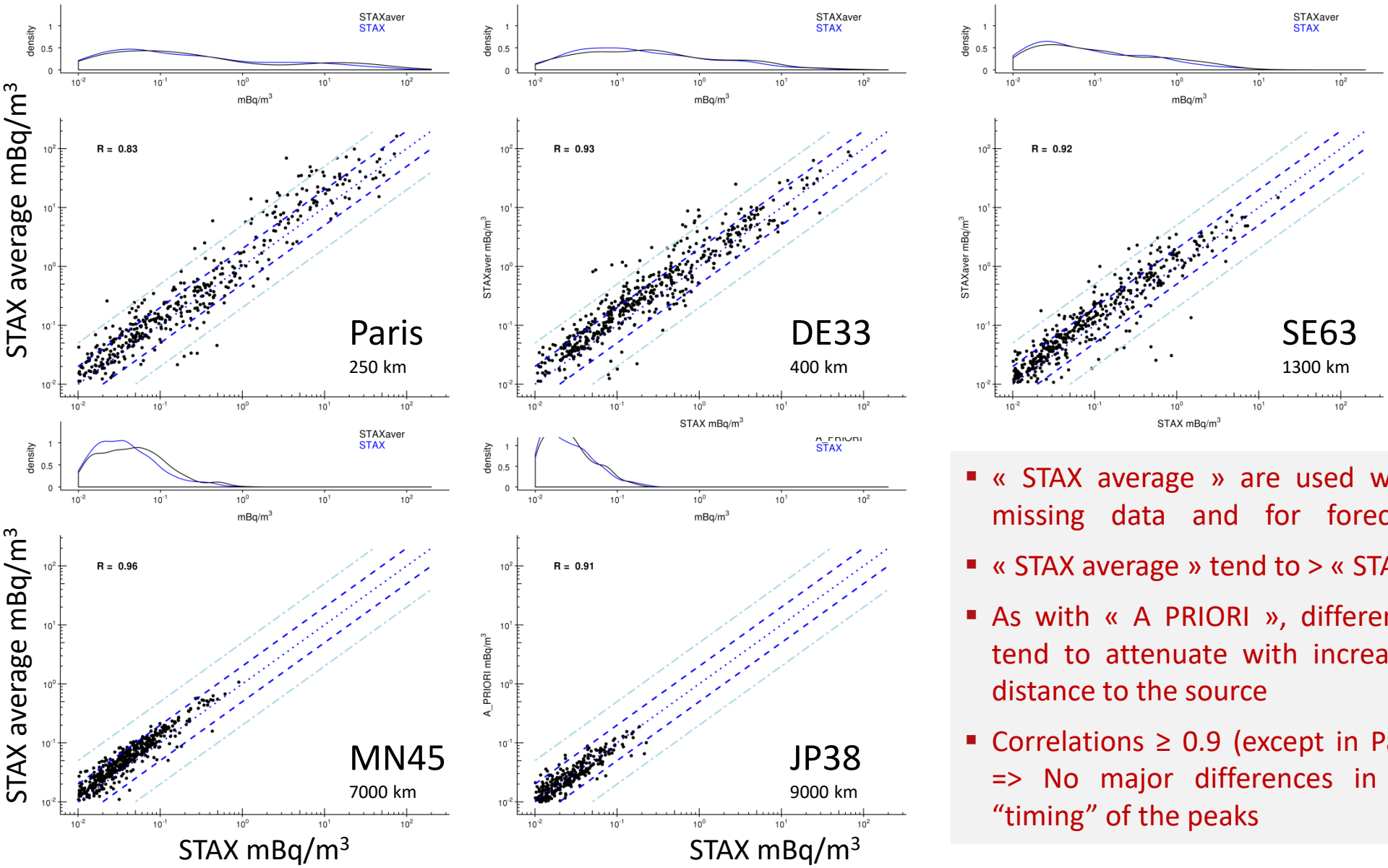


At JP38, differences are mostly within a factor of 2 and concern contributions ≤ 0.2 mBq/m^3

Same at JP38 (Takasaki, Japan)

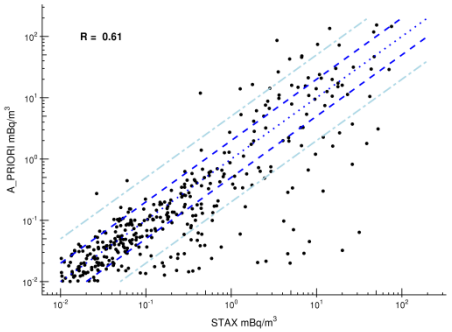
« STAX average » versus « STAX » (simulations versus simulations)

JUNE 2020-APRIL 2021



- « STAX average » are used when missing data and for forecasts
- « STAX average » tend to > « STAX »
- As with « A PRIORI », differences tend to attenuate with increasing distance to the source
- Correlations ≥ 0.9 (except in Paris) => No major differences in the "timing" of the peaks

Simulation time series and comparison to measurements



As scatterplot

(Same data) 12h-average activity concentrations simulated at Paris with IRE *a priori/stax* releases (Total of 648 points)

As time series

Measurements available / SPALAX (24 hours collection period)

PARIS

(IMS-like station)

XE133 mBq/ m^3

100
75
50
25
10
1

01/06/2020
01/07/2020
01/08/2020
01/09/2020
01/10/2020
01/11/2020
01/12/2020
01/01/2021
01/02/2021
01/03/2021
01/04/2021

A PRIORI STAX

« A priori » versus « STAX » : comparisons to measurements

PARIS

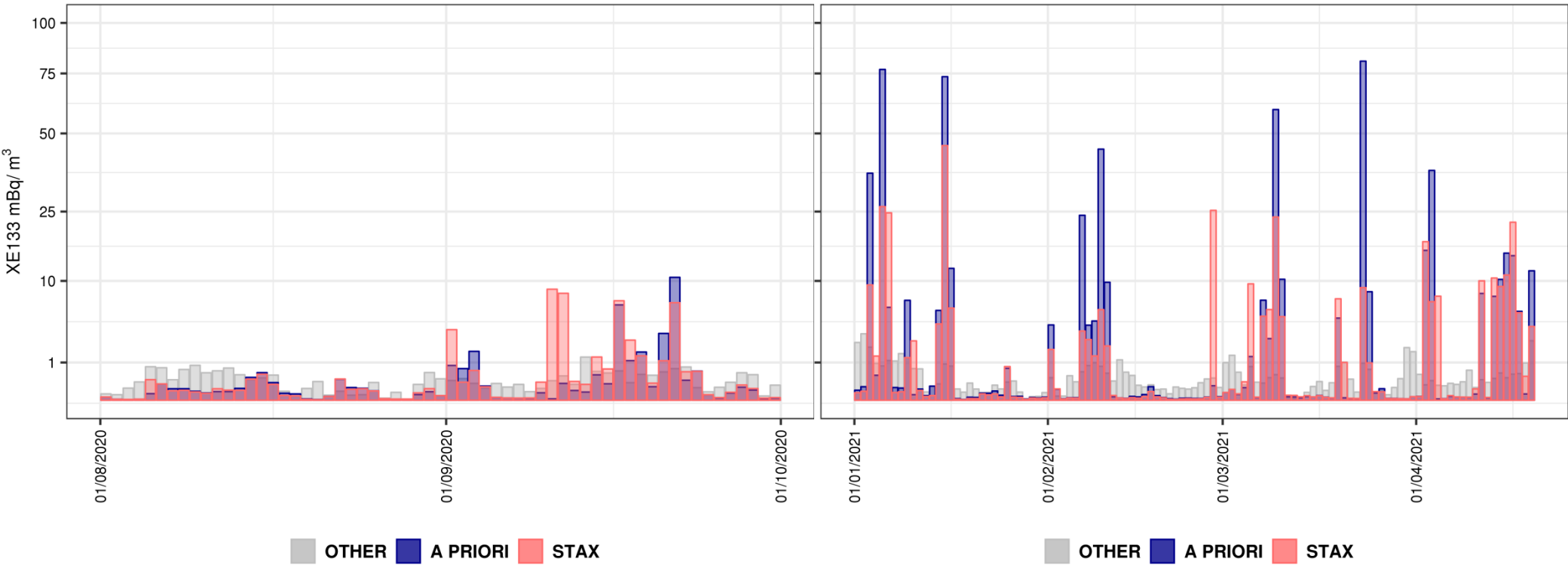
- Zoom in time
- **24h-average** (FROM 12H TO 12H)
- Other background contributors

(RUSSIAN MIPS, EUR AND ASIA NPPS)

Achim et al, *J. Env. Rad.*, 2021 :

- Fleurus is the major contributor of radioxenon background measured at Paris (6 month of SPALAX-NG measurement)
- ^{133}Xe background from other sources remain low

=> Measurements at this location are relevant for this study



« A priori » versus « STAX » : comparisons to measurements

PARIS

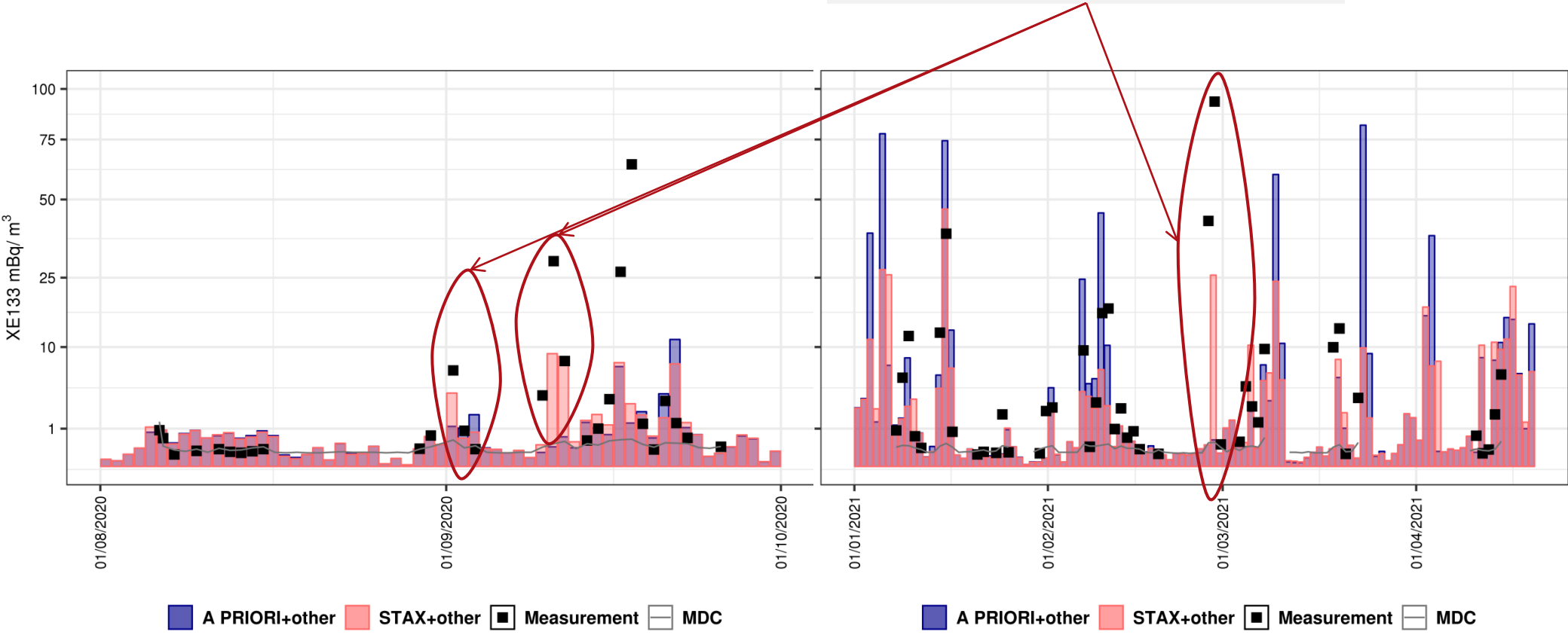
- Zoom in time
- **24h-average** (FROM 12H TO 12H)
- Other background contributors

(RUSSIAN MIPS, EUR AND ASIA NPPS)

- Measurements (FROM 17H TO 17H)

Peaks not seen with the « A priori »
=> The use of STAX data allowed to flag all the peaks measured => « screen out »

However, amplitudes are not all captured
=> meteorological and model uncertainties play an important part



« STAX average » versus « STAX » : comparisons to measurements

- Zoom in time
- **24h-average** (FROM 12H TO 12H)
- Other background contributors

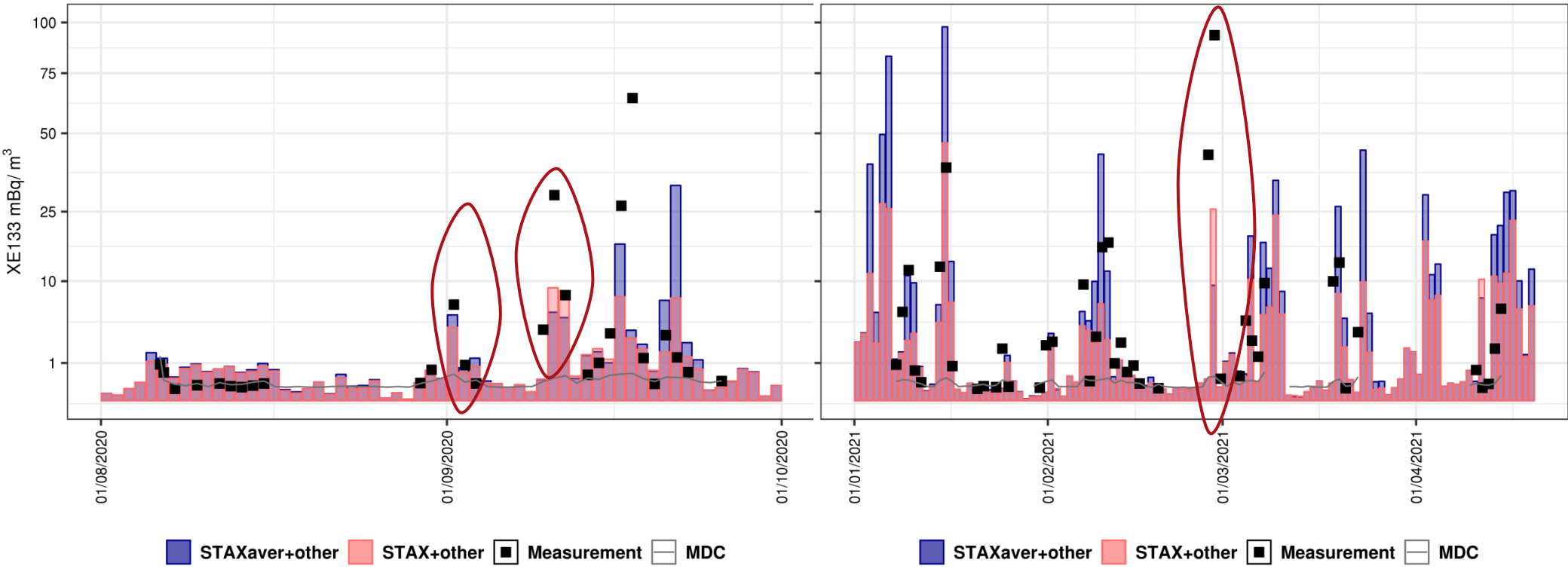
(RUSSIAN MIPS, EUR AND ASIA NPPS)

- Measurements (FROM 17H TO 17H)

PARIS

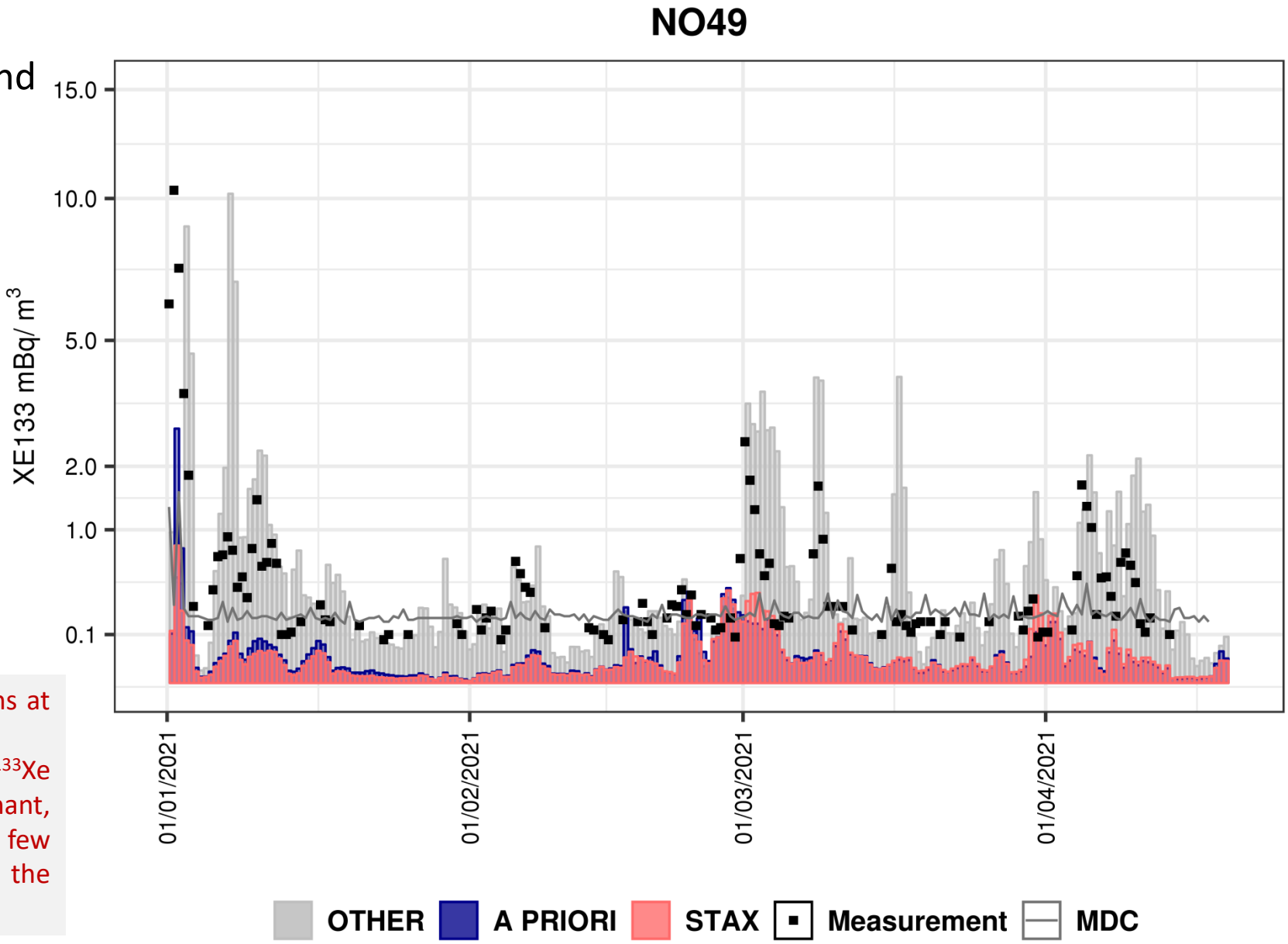
The use of « STAX average » leads to larger peak amplitudes than « STAX »

However, peaks not seen by the « A priori » are flagged => In the absence of real source term knowledge, a "smart" average carries useful information (« STAX average » ≡ average according to weekdays, and based on 1,5 year of STAX data)



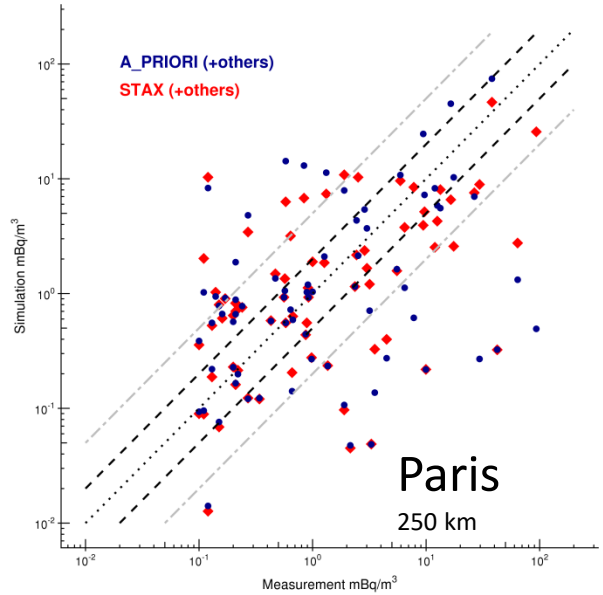
« A priori » versus « STAX » : comparisons to measurements

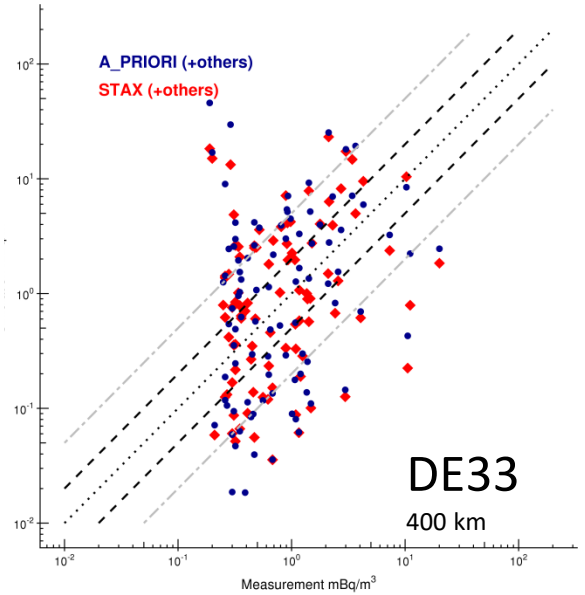
- Other background contributors (Russian MIPs, EUR and ASIA NPPs)
- 12h-average (00h-12h & 12h-00h)
- Measurements (05h-17h & 17h-05h)

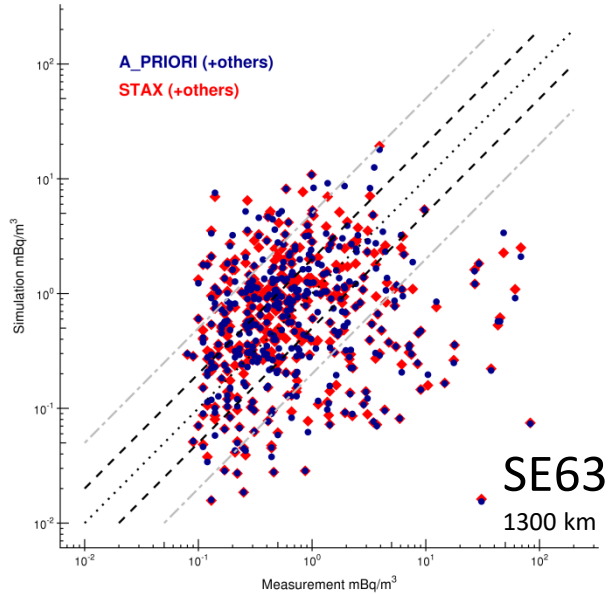


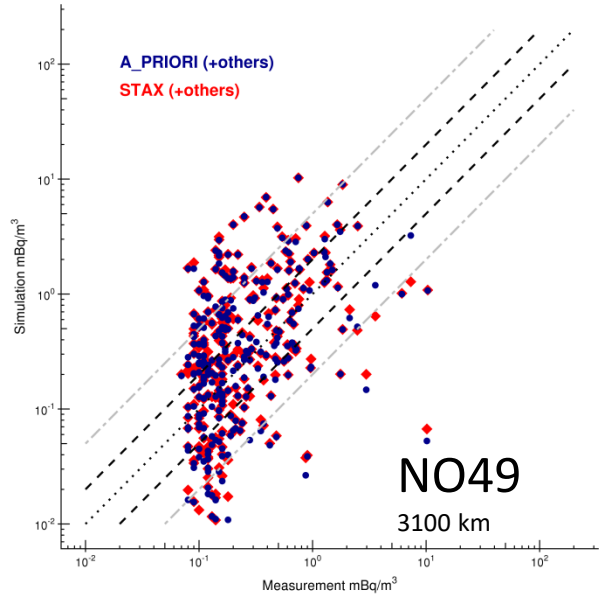
At NO49 (and for stations at distances further), IRE contribution to the ^{133}Xe background is not dominant, and has remained of a few tenth of mBq/m^3 over the period of the study

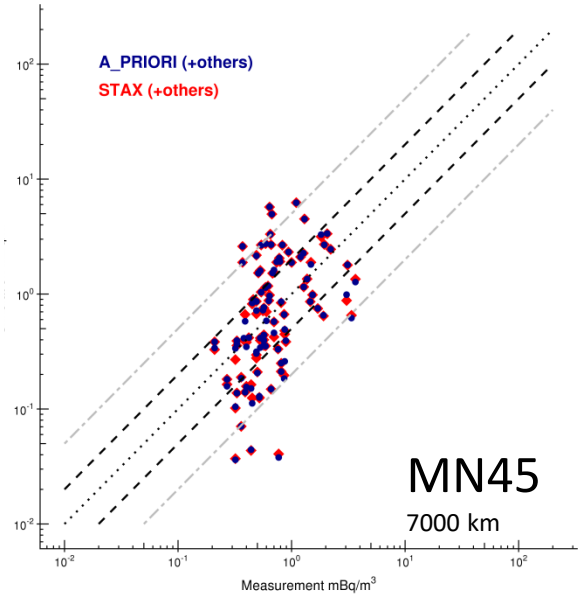
« A priori » versus « STAX » : comparisons to measurements

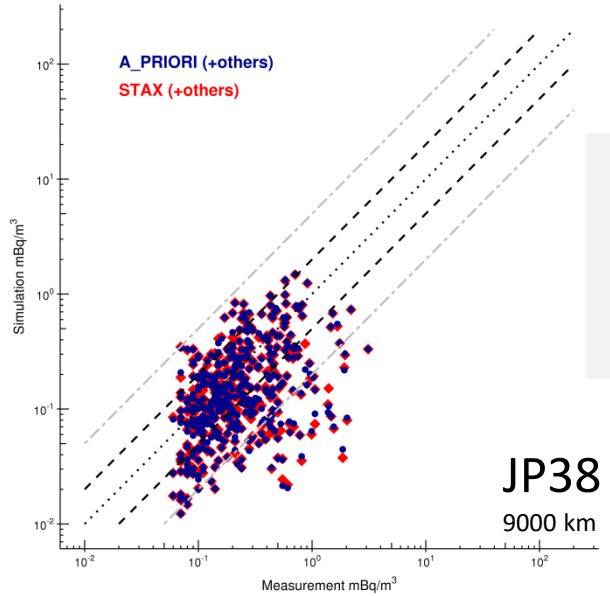












Differences tend to attenuate with increasing distances to the source

Conclusions

- STAX data (IRE) have been implemented into the automatic simulation of the global ^{133}Xe background at the French NDC. Data availability has been reliable and suited for operational use
- To ensure the operational functioning of the simulations and its forecast capability, if/when monitored emissions data are missing, average « real » releases are used according to weekdays
- Analysis of 1-year simulation time series with/without STAX data show differences at Paris (250 km from Fleurus) and at the closest IMS stations, but no detectable differences further than 1000-1500 km (in agreement with De Meutter et al, 2018, *JER*)
- Comparisons to measurements at Paris have shown improvement in the timing of simulated versus measured peaks. However, amplitudes of peaks are not all reproduced (in agreement with Goodwin et al., 2021, *JER*)
- Although not trivial due to other contributors, comparisons to measurements show that real emission data alone are not sufficient to properly reproduce all the measurements. Uncertainties in meteorological data and atmospheric modelling play an important role as well and have to be addressed
- STAX data from ANSTO will help further investigate this issue (major contributor to AUX04, 600 km away)

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