Creating time pattern models of radioxenon releases from nuclear facilities based on stack measurements

Martin Kalinowski[1], Matthias Auer[1], Ted Bowyer[2], Matthew Cooper[2], Charlie Doll[2], James Ely[2], Paul Eslinger[2], Judah Friese[2], Sid Hellman[1], Lori Metz[2], Mihaela Rizescu[1], Ramesh Sarathi[2], Brian Schrom[2], Cari Seifert[2]

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INTRODUCTION AND MAIN RESULTS

Data collected by the Source Term Analysis of Xenon (STAX) project are used to create source models for medical isotope production facilities and nuclear power plants.

Constant discharge rates assumptions are compared to the mean and the 95th percentile of STAX data. The frequency, shape and duration of puff releases is shown.

The source models' usefulness in nuclear explosion monitoring is demonstrated by comparing how well simulated concentrations with different source models can explain IMS observations.

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Time Pattern of Discharge Episodes

The constant discharge rate given as the total annual release[1] divided by 365 days is compared to the mean and the 95th percentile of STAX data.

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^{133}Xe	Constant from total annual discharge estimates[1] [Bq/d]	Mean of STAX data [Bq/d]	95th percentile of STAX data [Bq/d]	Comment
MIPF 1	2.36e+12	8.02e+10	2.47e+12	Constant close to 95th percentile
MIPF 2	1.52e+12	1.37e+12	1.08e+13	Constant close to the mean
NPP 1	4.99e+09	1.00e+9	2.40e+10	Constant right between mean and 95th percentile
NPP 2	1.10e+13	2.00e+7	2.78e+12	Constant much larger than 95th percentile

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Profile of ^{133}Xe puff releases from a nuclear power plant plotted against the time of day when it occurs (16 time in 27 months). The diagonal indicates a half-life of 5 hours.

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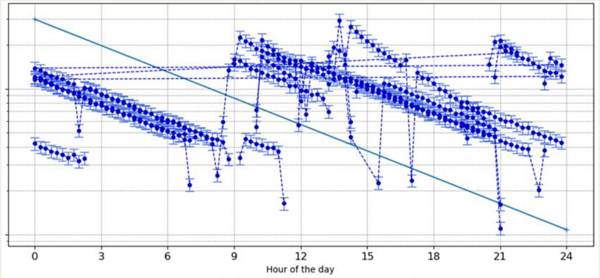

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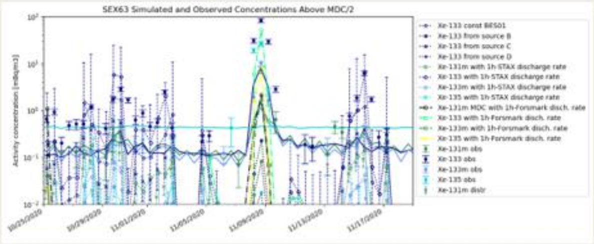
Method of Case Studies

Source variants used for concentration simulations:

1. Constant discharge rate = Annual discharge[1]/(365*24)
2. Distribution of discharge rates from STAX data
3. STAX data with one-/six-hour time resolution

Example of simulated and observed concentrations along time: AUX04 in Melbourne, Australia, with signals from a MIPF at 686 km distance.



Example of simulated and observed concentrations along time: SEX63 in Stockholm with signals from a regional NPP (Forsmark) and a MIPF (IRE) at 1305 km distance.

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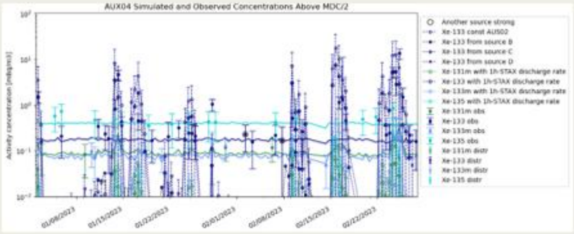

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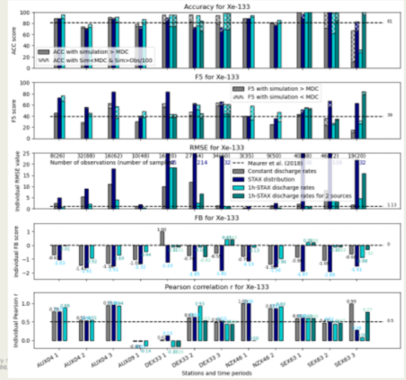
Simulated Concentration Performance

Top two subplots: High-resolution STAX data achieve the highest Accuracy. Distributions created from STAX data get in most cases best scores for Precision (F5). Middle plot: The RMSE is lower with high-resolution STAX data but highest for distributions created from STAX data.



Top two plots: High-resolution STAX data achieve in all cases the highest Accuracy. Distributions created from STAX data get in most cases best scores for Precision (F5). This is the percentage of all simulations within a factor of five from the observed concentration.

Middle plot: In most cases, the RMSE is lower with high-resolution STAX data compared to a constant release assumption. It is highest for distributions created from STAX data.

Bottom two subplots: Using STAX data with high time resolution gets the best scores for Fractional Bias (FB) and shows some improvements for the Pearson Correlation Coefficient.

The dashed lines indicate the performance scores of the IDC ATM software in the second ATM Challenge [Maurer et al., 2018]. It can serve as a reference since we are using the SRS files that are generated with the same IDC ATM software.

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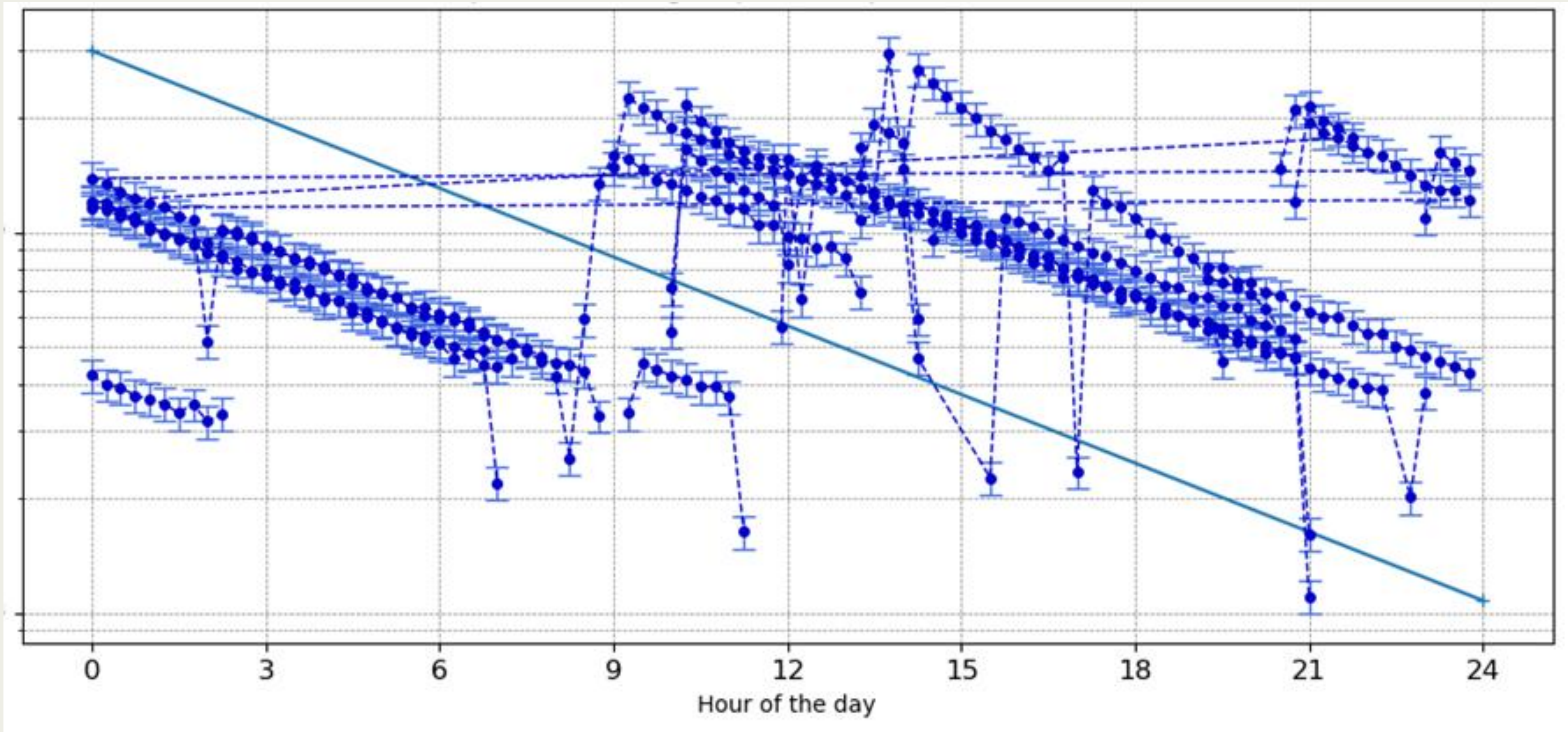

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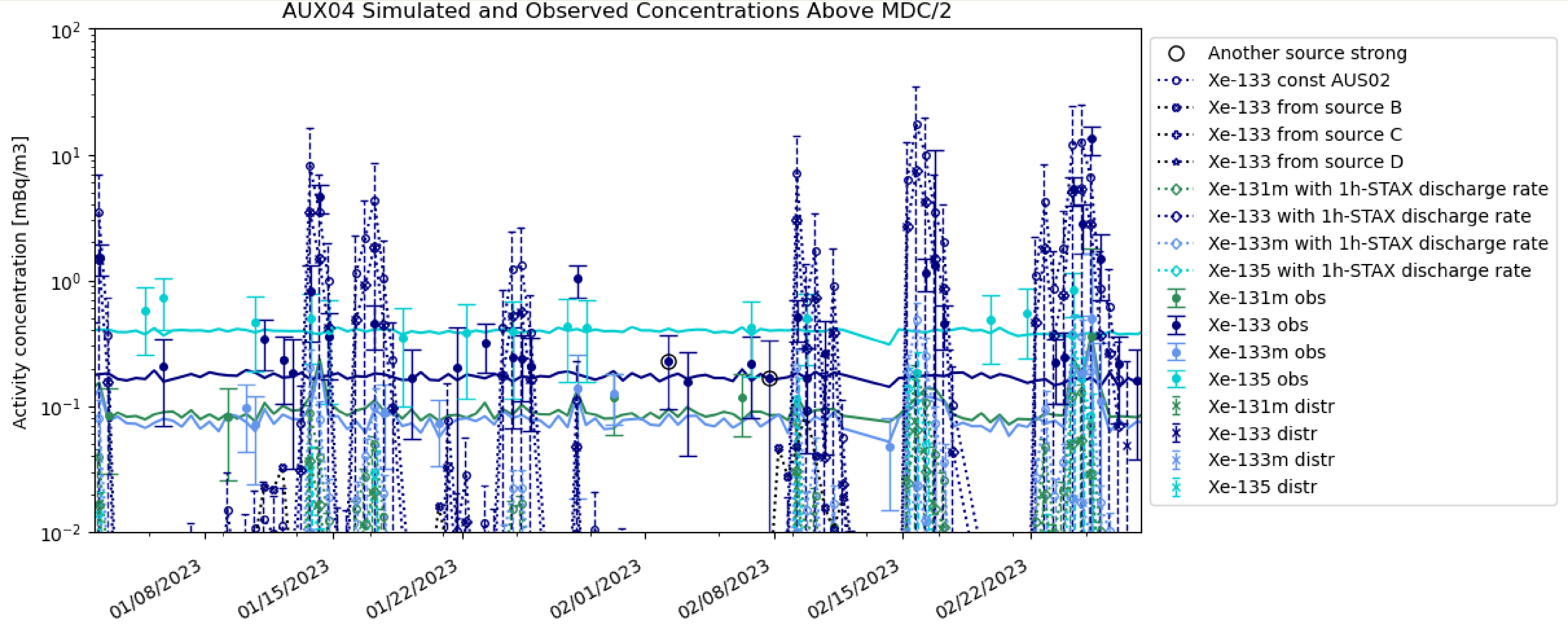

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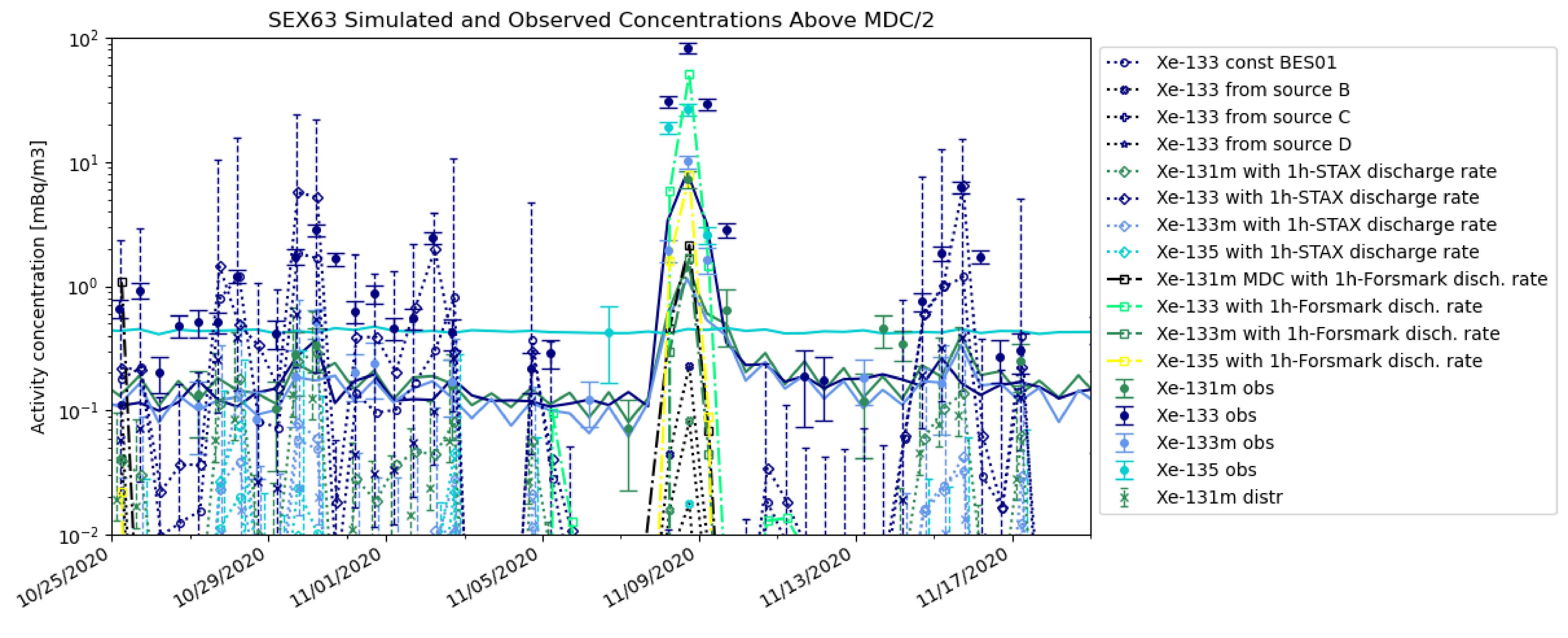

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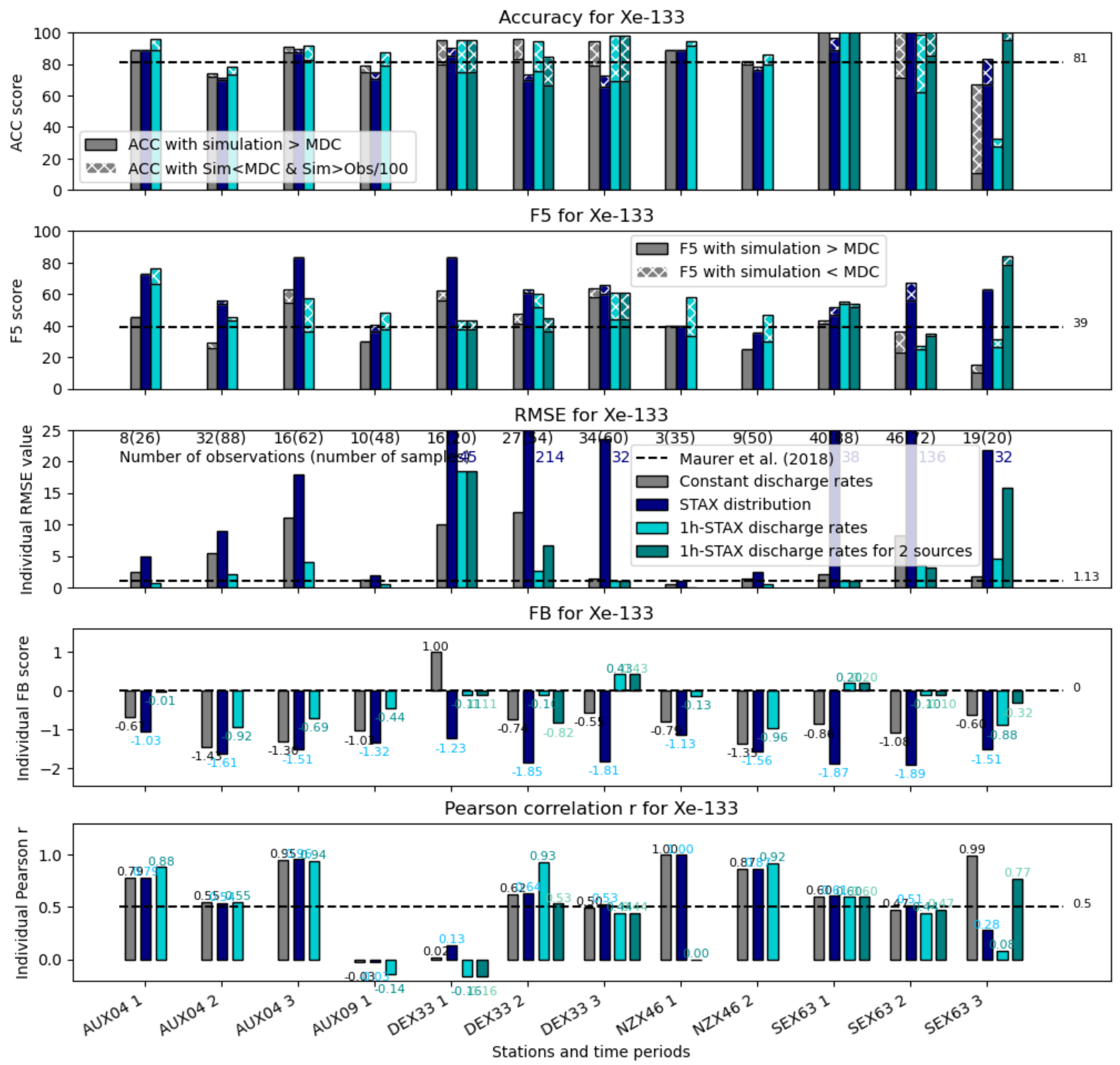

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