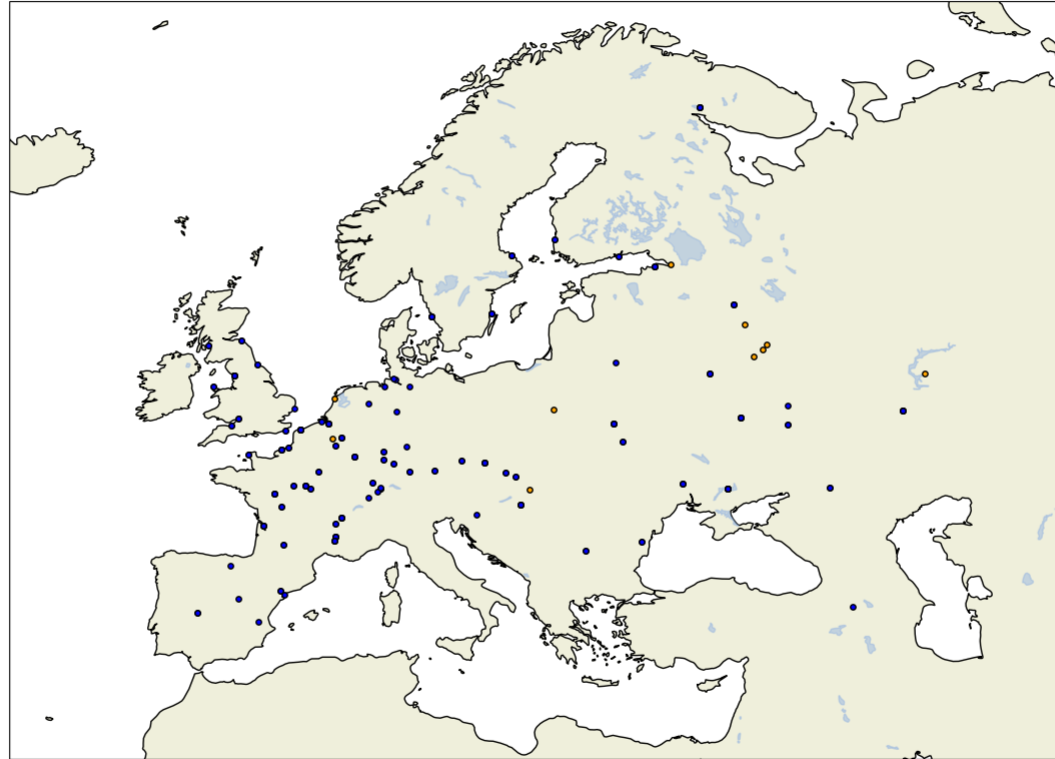




The Swedish Noble Gas Array – experience and future

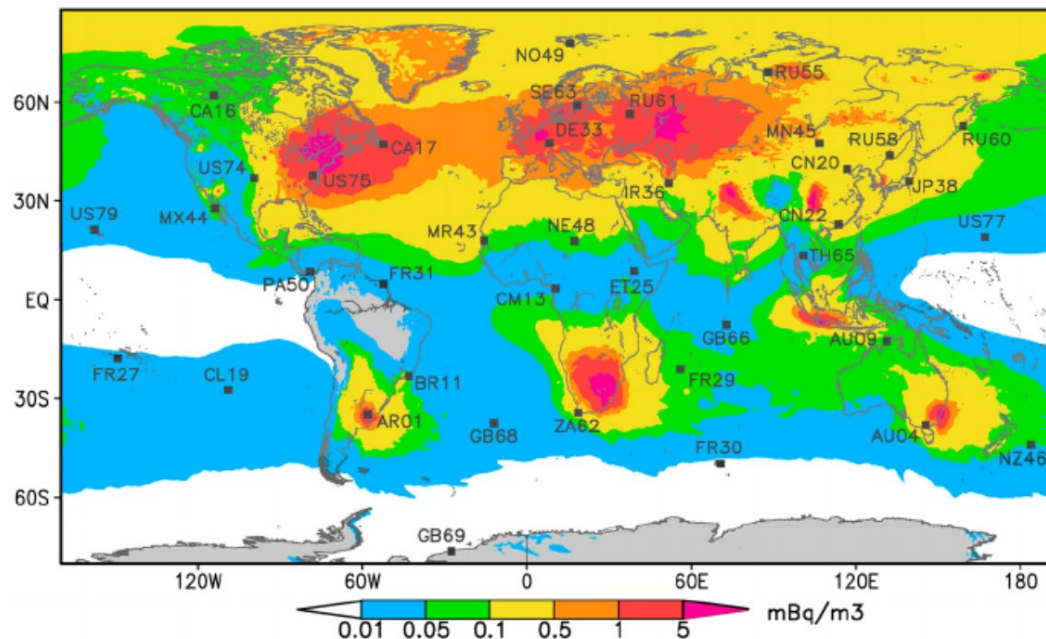
Klas Elmgren, Sofie Liljegren, Tomas Fritioff,
Mattias Aldener, Johan Kastlander, Henrik Olsson,
Anders Ringbom, Catharina Söderström

Sources of radionuclides in Europe



Xenon background in the atmosphere

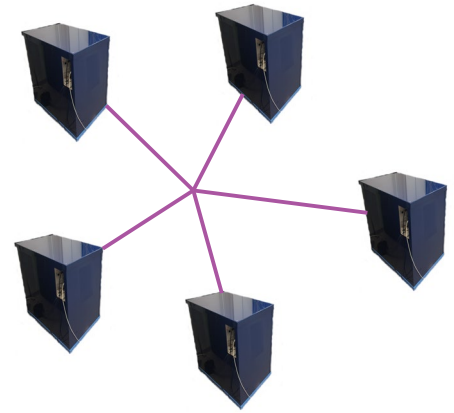
- Isotope production
- NPPs
- Medical use
- ...



Map from : Achim, P., S. Generoso, M. Morin, P. Gross, G. Le Petit, and C. Moulin (2016), Characterization of Xe-133 global atmospheric background: Implications for the International Monitoring System of the Comprehensive Nuclear-Test-Ban Treaty, J. Geophys. Res. Atmos., 121,4951–4966, doi:10.1002/2016JD024872

SAUNA Q_B

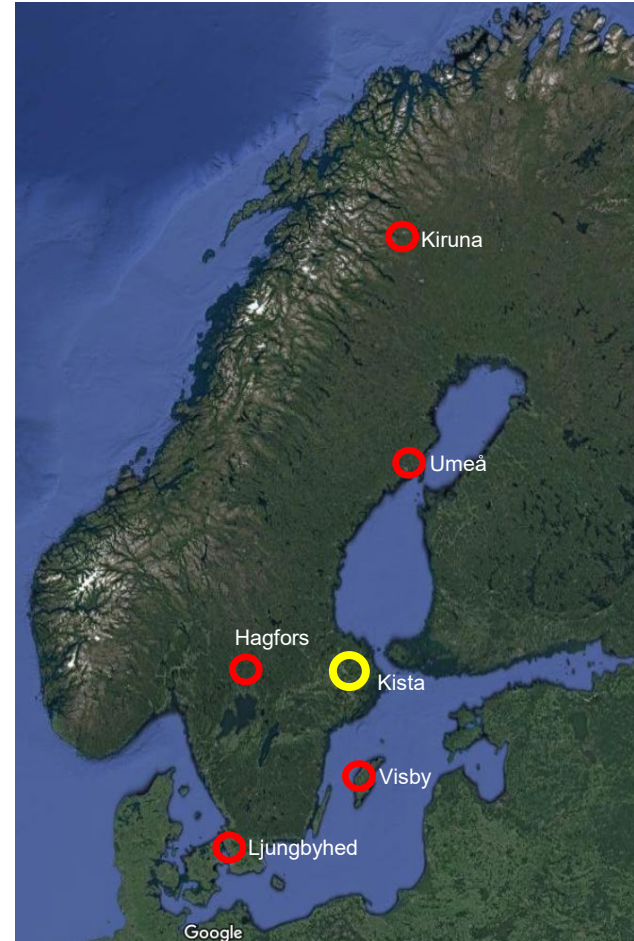
- A smaller, mobile and easily installed SAUNA system.
- Several units in a network improves the ability to localize a source.
- The sensitivity of each unit can be lower
→ each unit can be built at a lower cost





SAUNA Q_B – an array

- Five systems installed in Sweden
- Co-located with our air filter stations
- There is also an IMS NG-station, with a SAUNA III-system in Kista, Stockholm (SEX63).



Statistics from the network

- Data availability during 2021-05 -> 2023-02 (21 m, 648 d)
 - SEX63 – Kista – **601 days**
 - CUB01 – Hagfors – **396 days**
 - CUB02 – Umeå – **557 days**
 - CUB03 – Ljungbyhed – **457 days**
 - CUB04 – Visby – **476 days**
 - CUB05 – Uppsala/Kiruna – **256 days**
- Some initial problems, especially in Kiruna
- Ca 90 plumes of Xenon hits Sweden during this time → 1 plume a week with approx 15 observations per plume

Sample association with machine learning

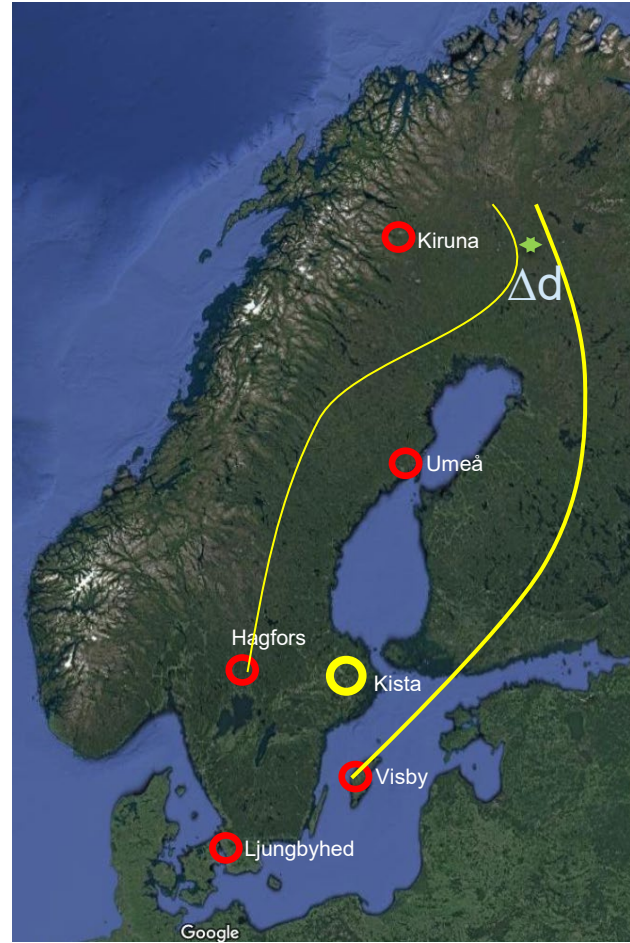
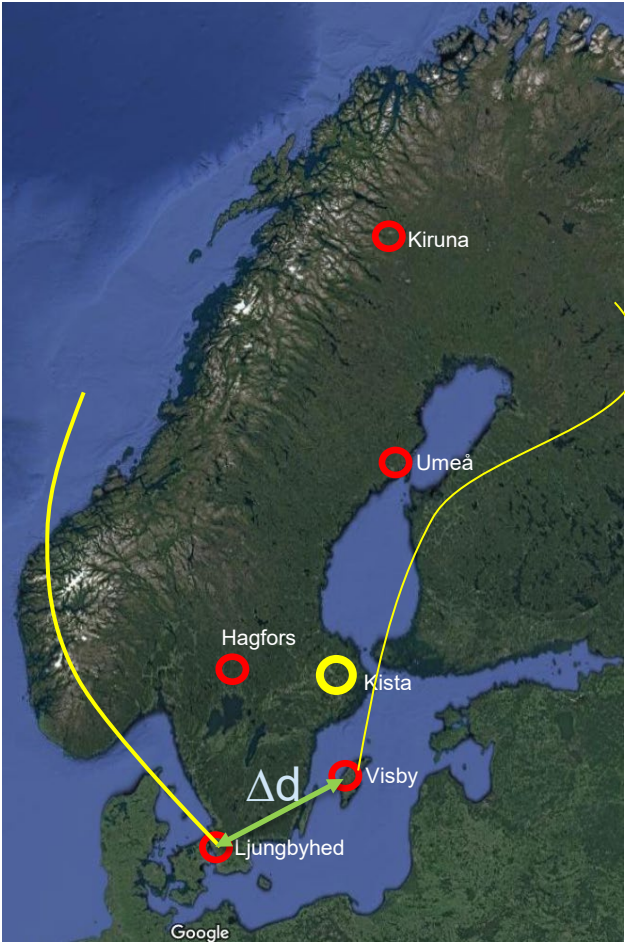
- Trained a neural network using synthetic data, where the answer is known.
- The synthetic data is ~3000 simulated events, randomly distributed in time and space over 2018, in Europe.
- Evaluates if two samples, s_1 and s_2 , are associated or not.

Sample association with machine learning

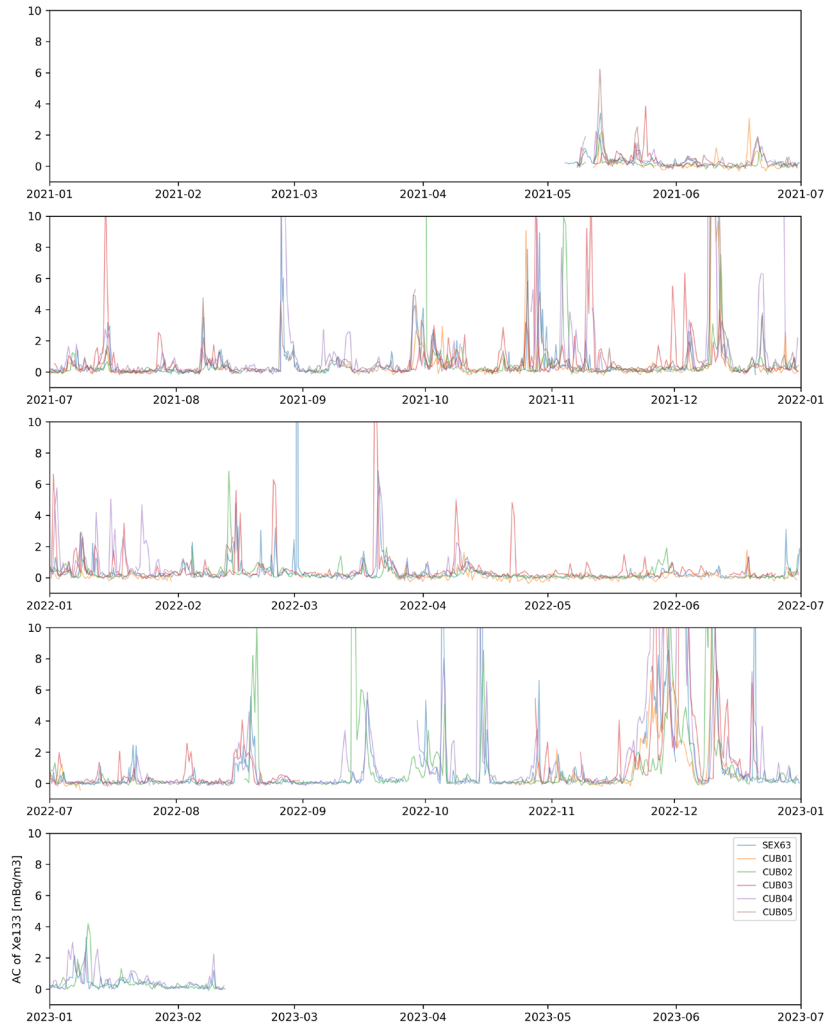
The input properties to the network N are:

- The **activity concentrations** of s_1, s_2
- The **distance between the stations**
- The **time difference** of the detections
- The **minimum distance** of the Hysplit backwards **trajectories**.

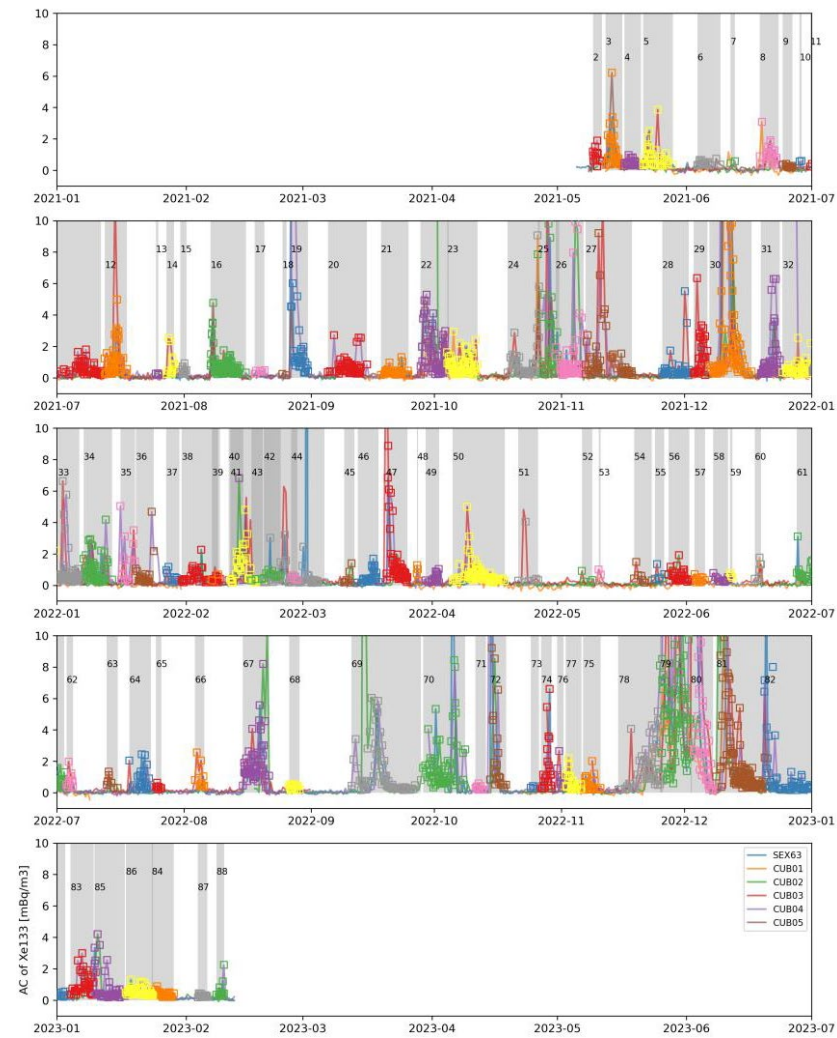
$N(ac_1, ac_2, \Delta d, \Delta t, \min(\Delta traj))$ will return **1** if the two samples are associated and **0** if they are not.



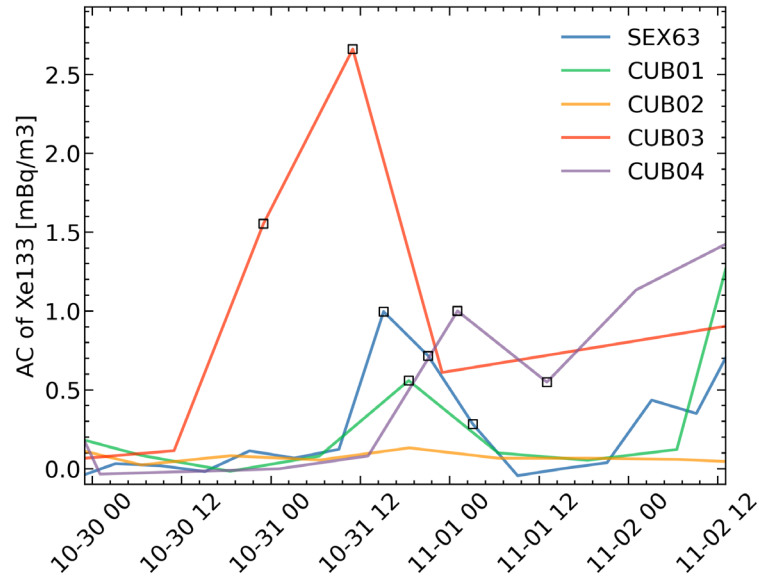
Time series for the whole network



- The ML algorithm was applied on data from the Swedish Cube array + SEX63 and Hysplit trajectories
- 86 plumes identified over 22 months → around one plume per week hits Sweden
- ~20 samples per plume



Case 1 - Fleurus



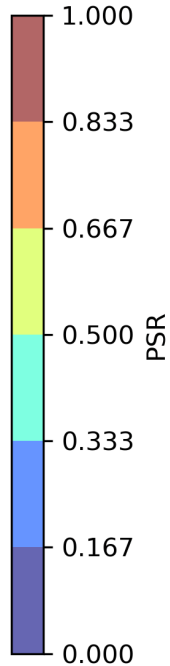
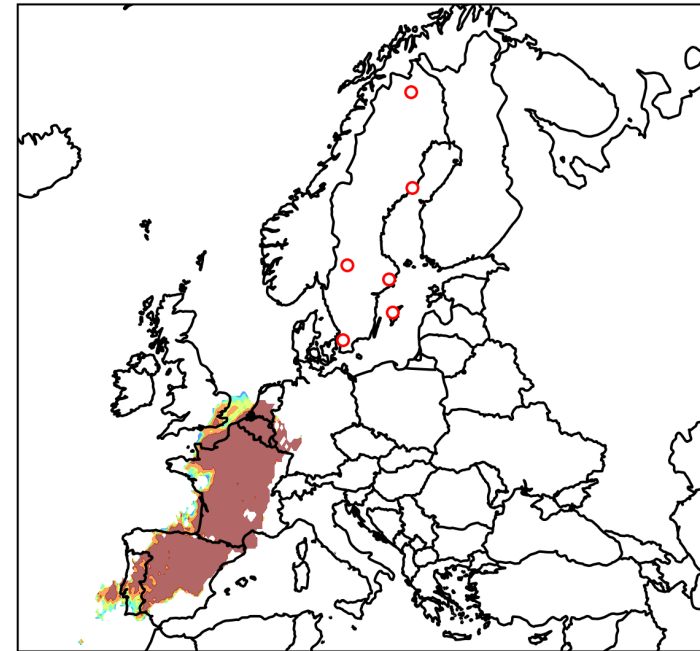
Ljungbyhed

Hagfors

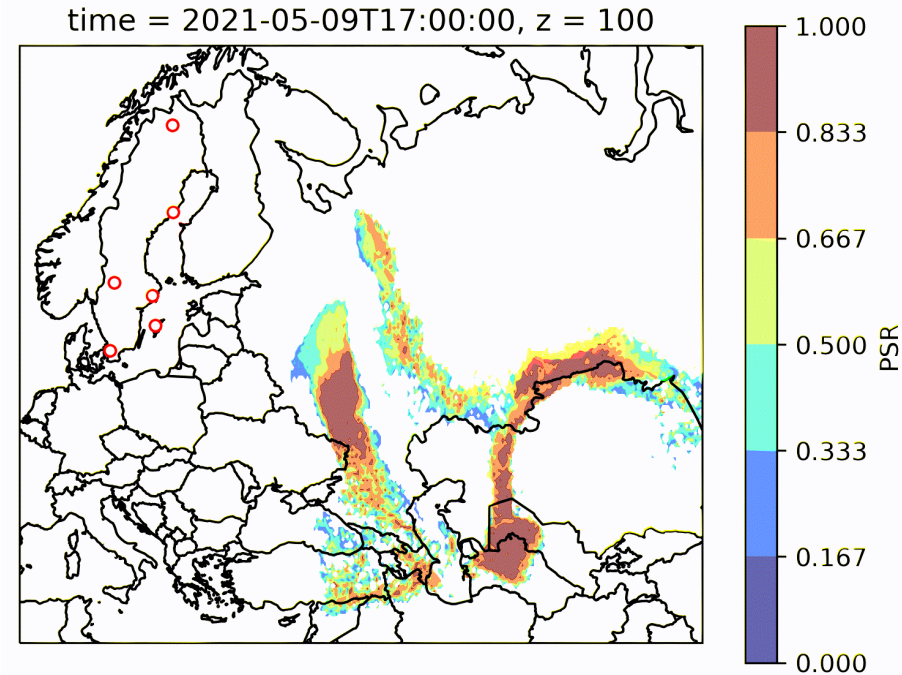
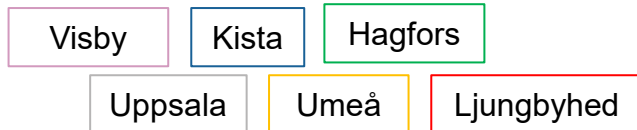
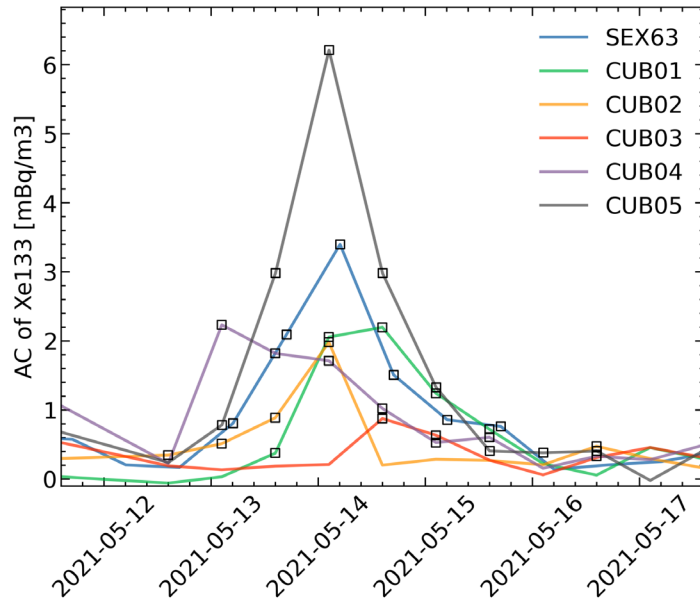
Kista

Visby

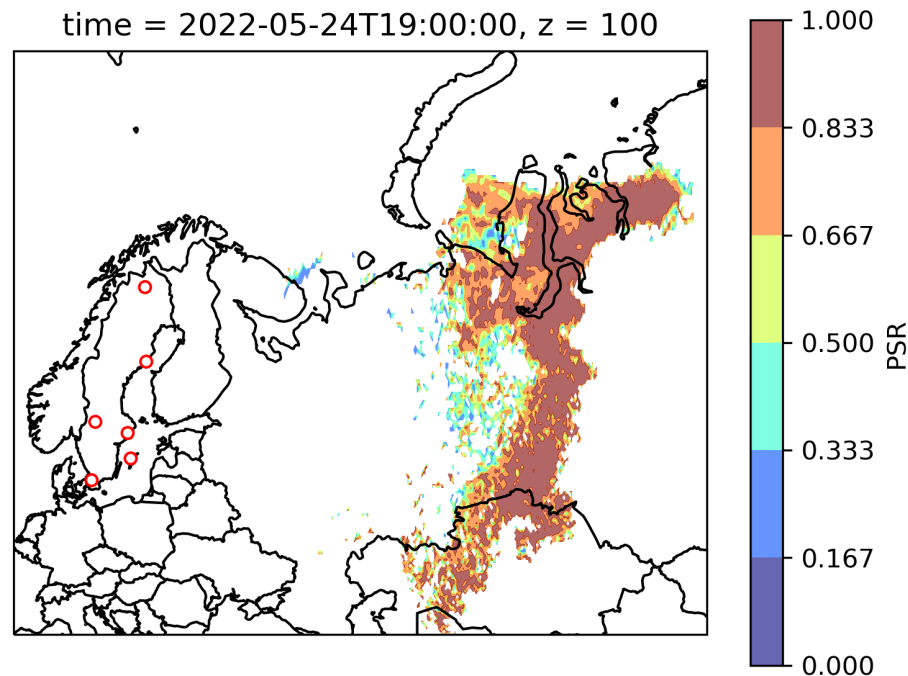
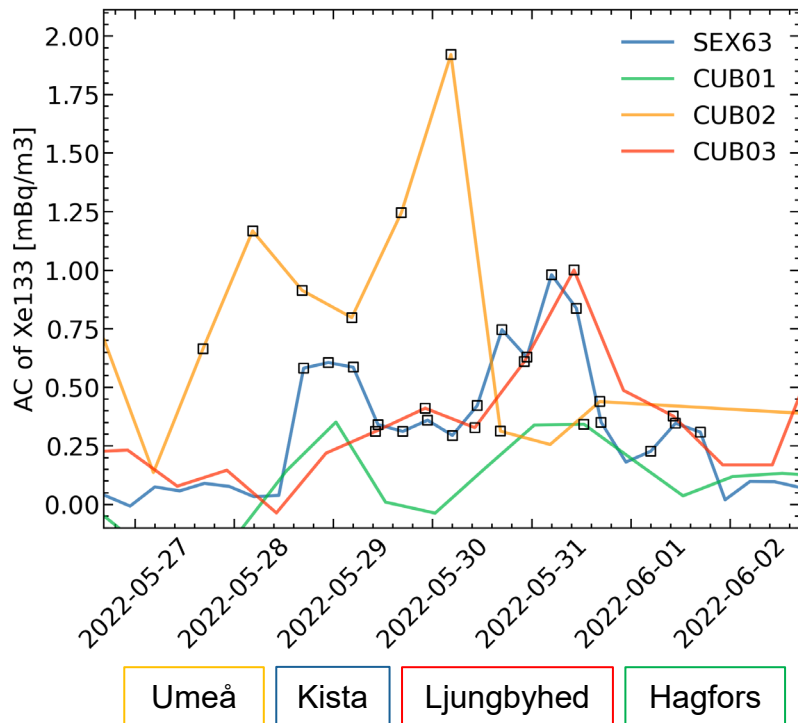
time = 2022-10-28T13:00:00, z = 100



Case 2 – Russia / Eastern Europe



Case 3 – Northern Russia



Conclusions

- The array concept works!
- An array is a powerful tool to identify radionuclide sources.
- Several detections from different locations reduce PSR
- Identification of samples with common origin could be performed using ML
- An extension to cover larger areas would be desirable

Future

- Improve data availability. (Spare parts, manpower...)
- Develop array analysis tools.
- Automate ATM calculations.
- Include non-detections in calculations.
- Include release data (STAX, etc.)
- Expand the network?

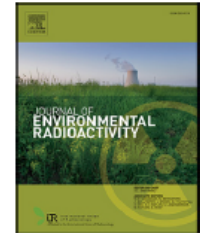


ELSEVIER

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad



SAUNA Q_B - Array: The realization of a new concept in radioxenon detection

Anders Ringbom^{a,*}, Tomas Fritioff^a, Mattias Aldener^a, Anders Axelsson^{a,1}, Klas Elmgren^a, Carl Hellesen^a, Lindsay Karlkvist^a, Johan Kastlander^a, Henrik Olsson^a, Helena Berglund^b, Bo Hellman^b, Ola Pettersson^b

^a Swedish Defence Research Agency (FOI), Gullfossgatan 6, SE-16490, Stockholm, Sweden

^b Scienta Sensor Systems AB, Danmarksgratan 22, SE-753 23, Uppsala, Sweden



<https://doi.org/10.1016/j.jenvrad.2023.107136>