SnT 2023

CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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The development of an association algorithm for radionuclide measurements

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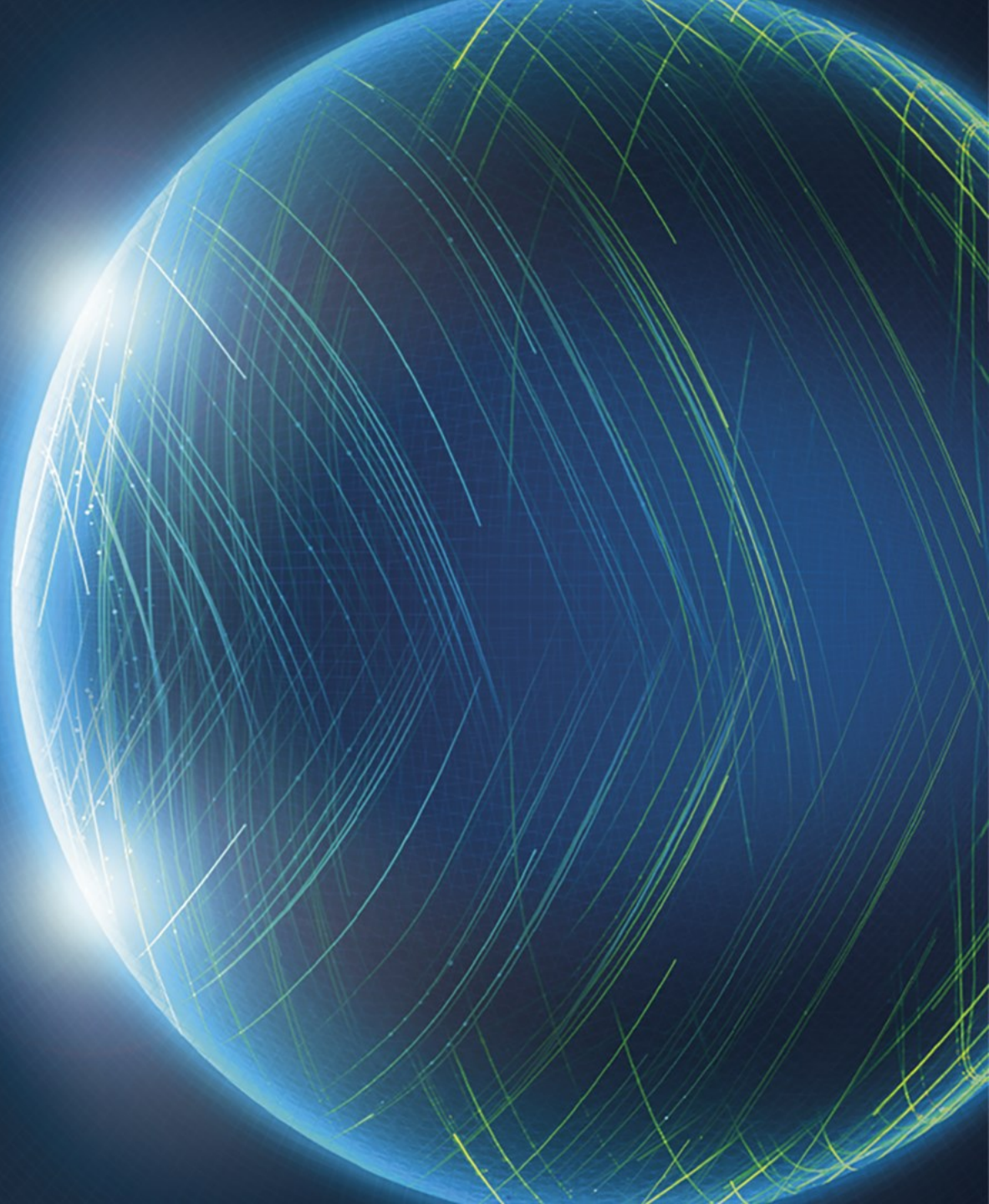


Goal: Implement a Radionuclide Data Pipeline that Focuses on Release Events rather than Samples using Data Fusion

IMS System

Spectrum and Analysis

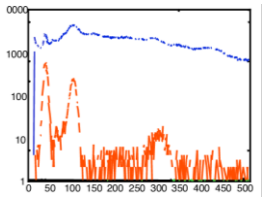
Sample Flagged as L5/LC

Sample Automated RN Report

Sample Reviewed RN Report

Analyst Review

Sensitivity & Selectivity



IDC Algorithm and Lists

Transport Parameter Calculations

Fused Event Bulletin

Waveform Fusion

Bayesian Analyses

Detect Anomaly

Find Associated Samples

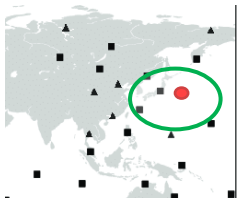
Estimate T_0, Release Strength, Location

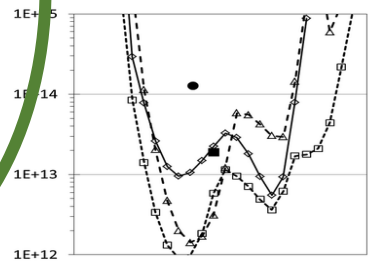
Analyst Review

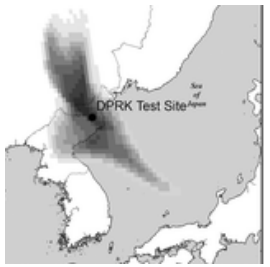
EVENT Bulletin 1

EVENT Bulletin 2

Includes local BKG

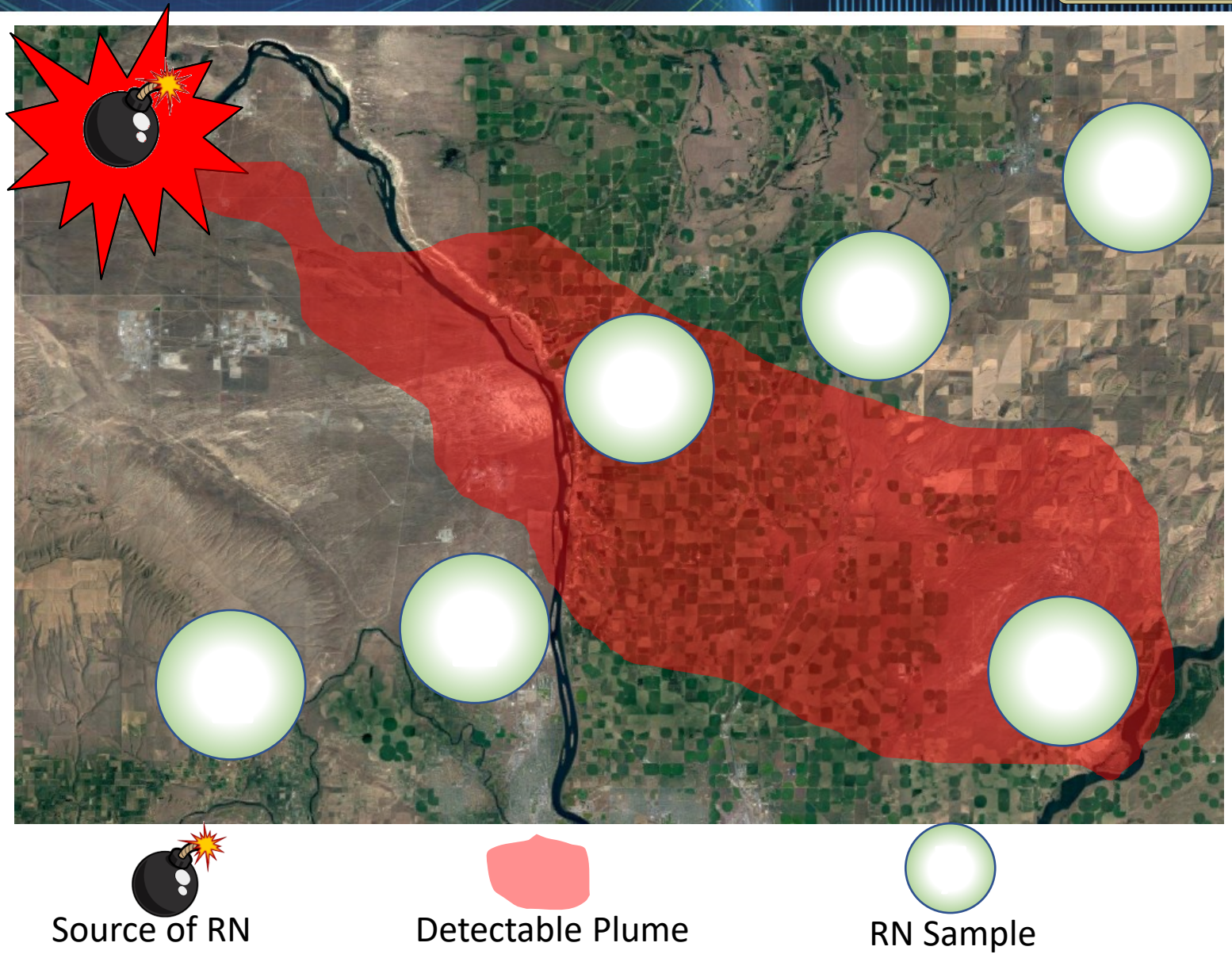






What is 'Sample Association'?

- Selecting the measurements to use in forming a release event
  - Detect: 3 & 4
  - Locate: 2, 3, 4, & 5
  - Ignore: 1 & 6
- Concept:
  - Use air measurements from inside and near the plume to define the event
  - Exclude measurements a long distance from the plume



Summary and Status

- A first-generation automated association approach has been constructed
  - Objectively selects neighbor samples in time and space
  - Returns results quite similar to what an expert analyst would pick
- This tool uses transport calculations averaged in some way…
  - Full year of past air transport
  - Current season for several years (e.g. Spring ‘20, Spring ’21, Spring ‘22)
  - Custom period, such as last two weeks
- The atmospheric transport model computations can be accumulated over time

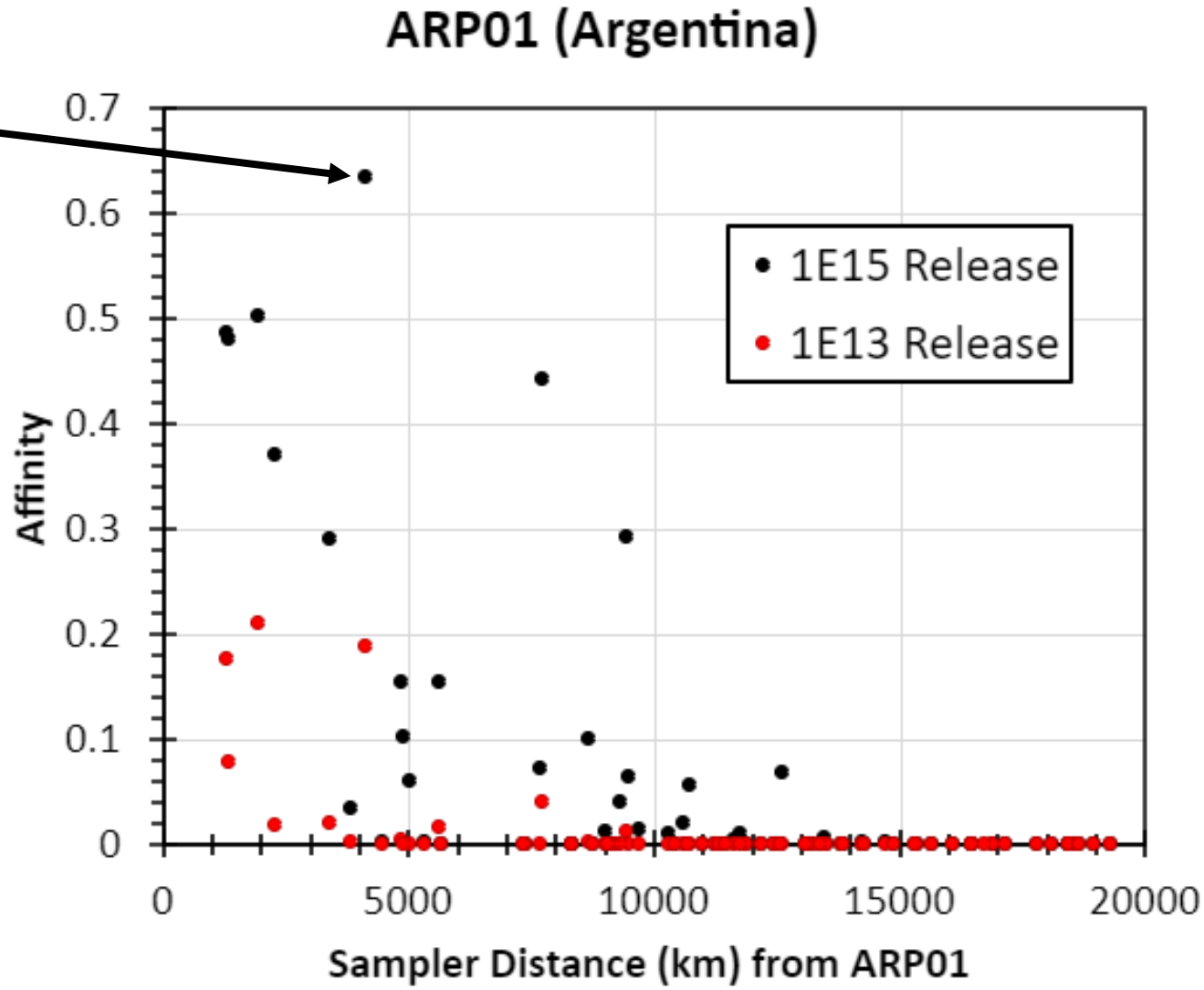
Computational Approach

- Approach
  - Conduct a large set of atmospheric transport runs for RN sampling locations
    - 79 stations for one year (2014 meteorological data)
  - Examine predicted detections at each station for a large number of possible release events spread across the globe
    - Synthetic releases every 3 h for a year at 100,000 locations
  - Build a huge matrix of “detect/not detect” status on all release events for every RN station
- Define an “affinity” for plumes that pass over more than one station
  - Given that station “A” has detected some subset of the releases, what fraction of those same releases are detected at station “B”?
  - Can precompute and store “affinities” for each sampling location

Example Affinity Results for ARP01

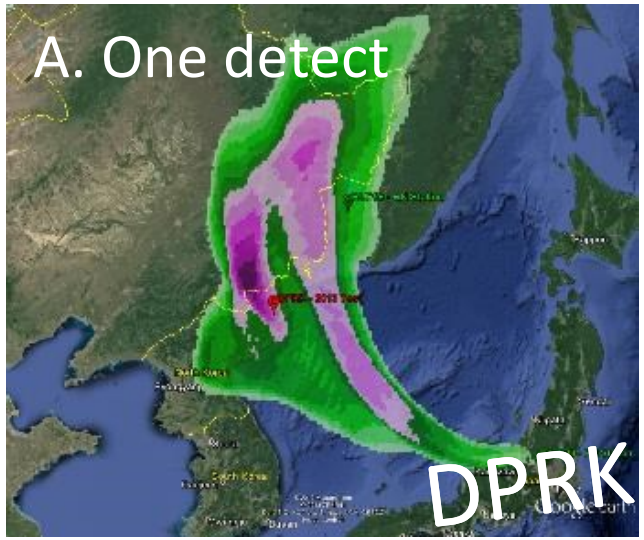
For large releases, stations that most often have detections from the same plume can be a long distance apart.

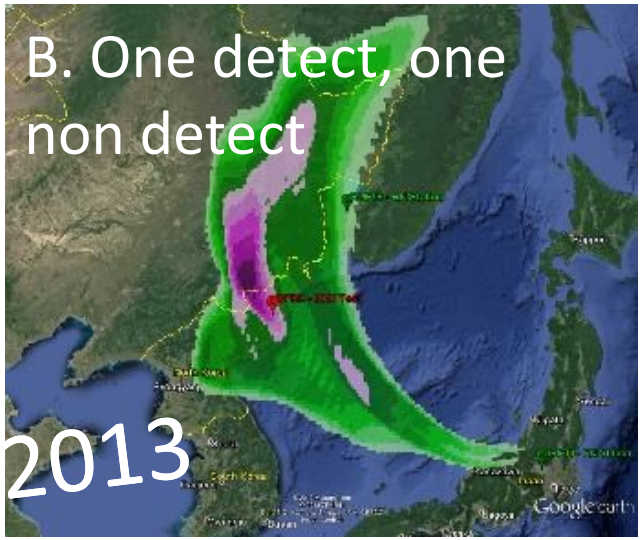
- Example calculations:
  - Releases of ^{133}Xe and current sampler detection limits
  - The affinity value depends on the release magnitude
  - Smaller releases have lower, more limited affinity

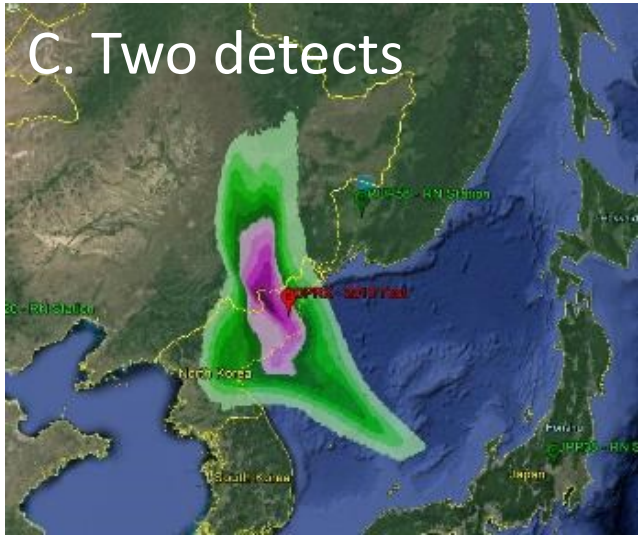


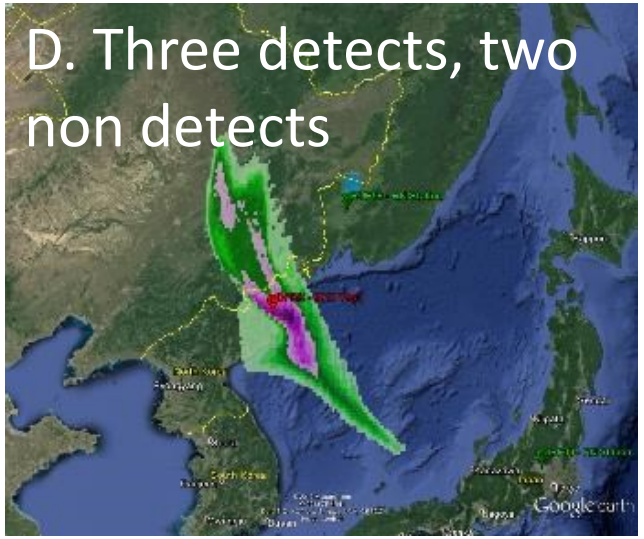
79 Station network

Affinity Matches Expectations from Past Event Analysis







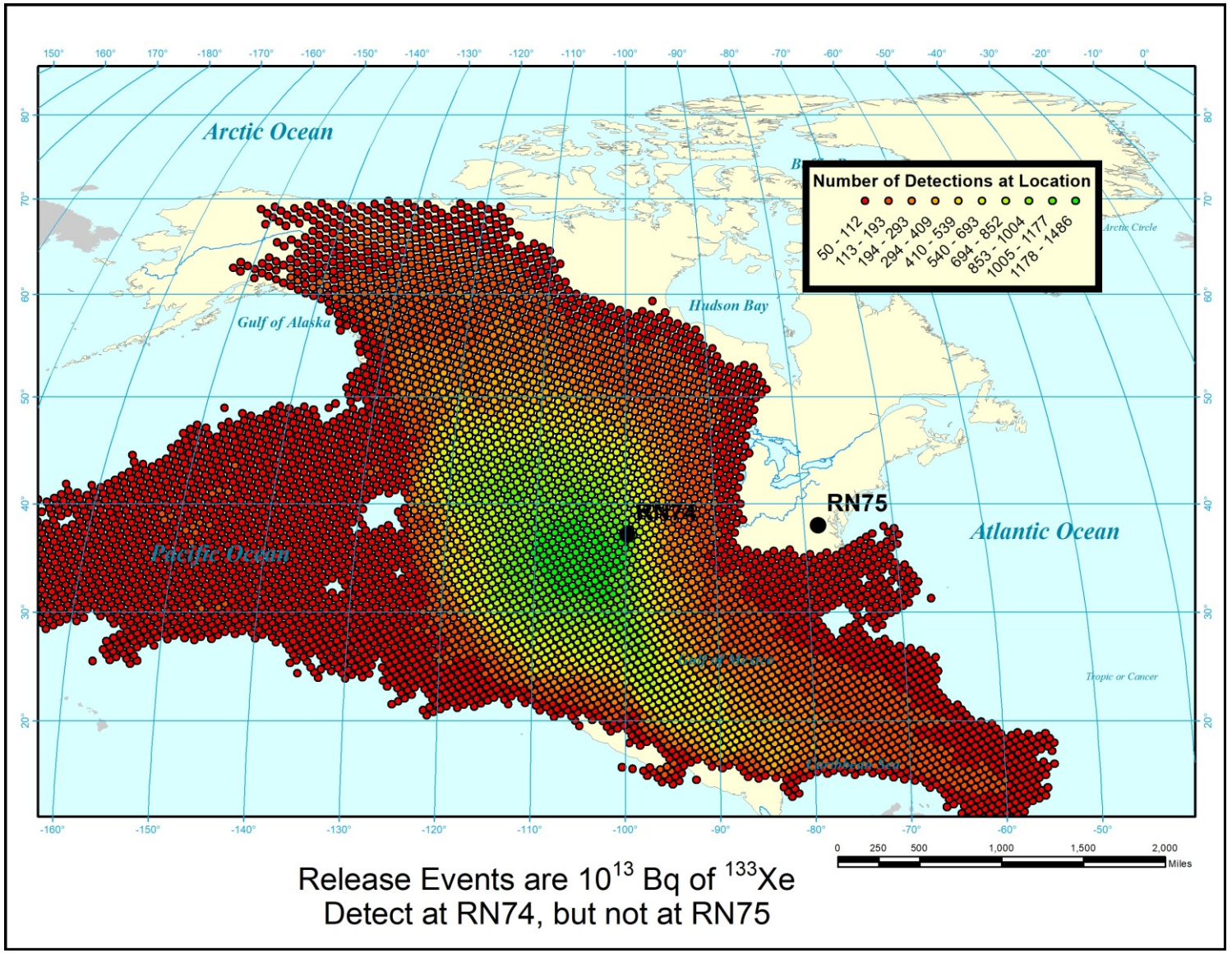


Example Affinity to JPX38 (Takasaki) for a 10^{13} Bq ^{133}Xe Release Event

Station	Dis (km)	Affinity	(Name)
RUP58	1058	0.2463	Ussuriysk
JPP37	1518	0.2126	Okinawa
RUP60	2412	0.0931	Petropavlovsk
CNP20	2019	0.0454	Beijing
PHP52	2988	0.0439	Tenay
USP78	4157	0.0417	Midway
MNP45	2964	0.0391	Ulan Bataar
USP71	4950	0.0237	Sand Pt AK
RUP56	3210	0.0167	Peleduy
CNP22	2877	0.0166	Guangzhou
USP77	3284	0.0148	Wake Island
THP65	4603	0.0117	Bangkok
USP80	2595	0.0105	Guam

Other Uses of the Affinity Data

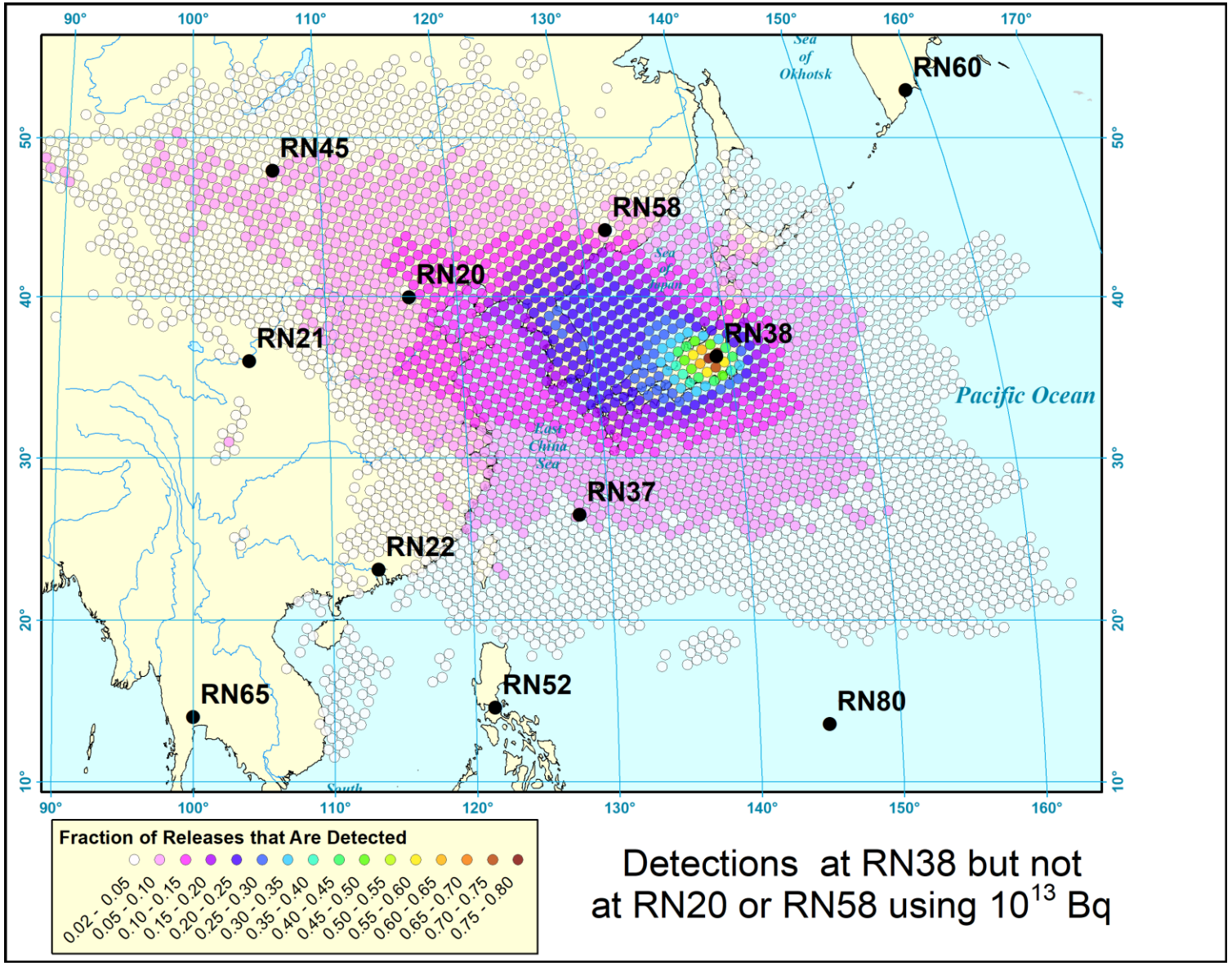
- Approach
  - Use the matrix of “detect/not detect” status on all releases for every sampler
  - Compare common detections at pairs or groups of samplers
- Build a map of detections that matches your detection rules
  - Example: Detect release at RN74 but not at RN75
  - How many of the 100,000 releases have consistent detections?



Release Events are 10^{13} Bq of ^{133}Xe
Detect at RN74, but not at RN75

A More Complex Joint-Association Example Using Historical Meteorological Data

- Data Set
  - Use the matrix of "detect/not detect" status on all releases for every sampler
- Build a map of detections that matches your detection rules
  - Releases every 3 h of 10^{13} Bq of ^{133}Xe at 100,000 locations
  - Noble gas detectors at RN20, RN38, and RN58
  - How many releases are consistent with detections at RN38 but not RN20 or RN58?



Detections at RN38 but not at RN20 or RN58 using 10^{13} Bq

Conclusions

- A sample association approach has been constructed that can be automated for screening analyses
  - Objectively selects neighboring samples in time and space
  - Returns results quite similar to what an expert analyst would pick
  - Uses averaged historical air movement
- Once developed, the data matrix of “detection status” for release events becomes a lookup table
  - Provides an initial selection of other samples an analyst might examine when evaluating a first detection
  - Provides an initial look at possible source regions
- The initial sample association is a launching point for analyst review

Questions?