A KRYPTON-85 MONITORING REGIME TO DETECT CLANDESTINE PLUTONIUM SEPARATION IN THE MIDDLE EAST

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57th INMM Meeting, Atlanta, Georgia, July 2016

Revision 3b

BACKGROUND AND MOTIVATION

DETECTING CLANDESTINE SEPARATION OF PLUTONIUM

- Precedents exist for attempts to make plutonium in undeclared facilities
- Concern of “Simple, Quick Processing Plant” (Oak Ridge, 1977)
- Challenge for NPT verification; also relevant for future FMCT verification
- Atmospheric (krypton) sampling appears most promising (“STR-321”)

FINDINGS AND RECOMMENDATIONS FROM “STR-321” (1996–1998)

- The cost of operating a WAES network “could be high and would be strongly dependent on: the type of facility …; the target region to be covered; and the acceptable probability of detection and false alarm rate”
- Recommended additional work includes: “Refining evaluation of the variability in background levels of target signatures”

Ned Wogman, *History of STR 321: IAEA Use of Wide Area Environmental Sampling In the Detection of Undeclared Nuclear Activities (1996–1998 Multi-country Effort),* PNNL-SA-75565, November 2010

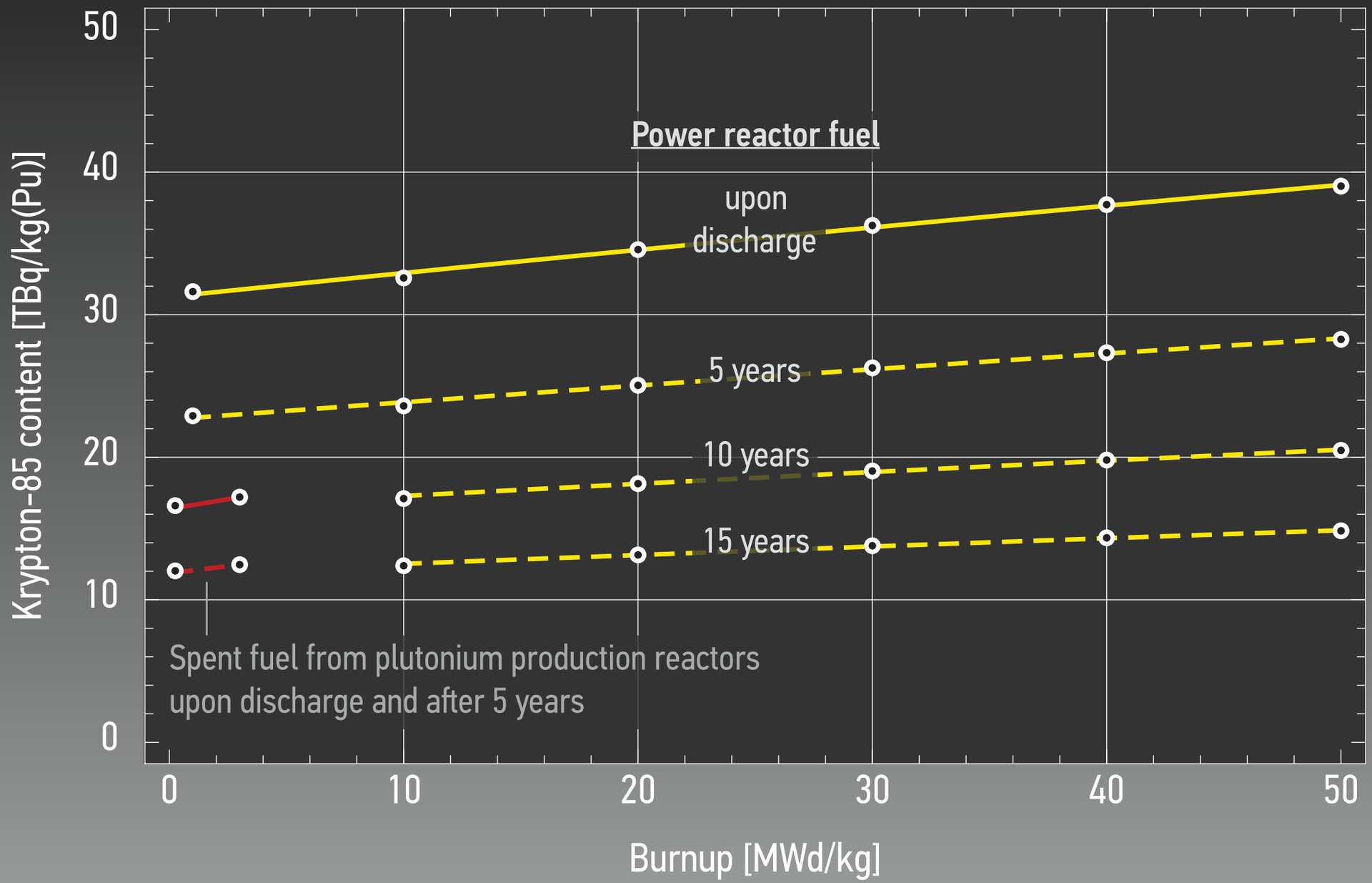
AN AIR SAMPLE IS TAKEN SOMEWHERE ON THE GLOBE (OR IN A REGION)

IS THE MEASURED KR-85 CONCENTRATION FROM A KNOWN OR FROM AN UNKNOWN PLANT?

HOW WOULD A VERIFICATION REGIME LOOK LIKE?

KRYPTON-85 CONTENT IN SPENT FUEL

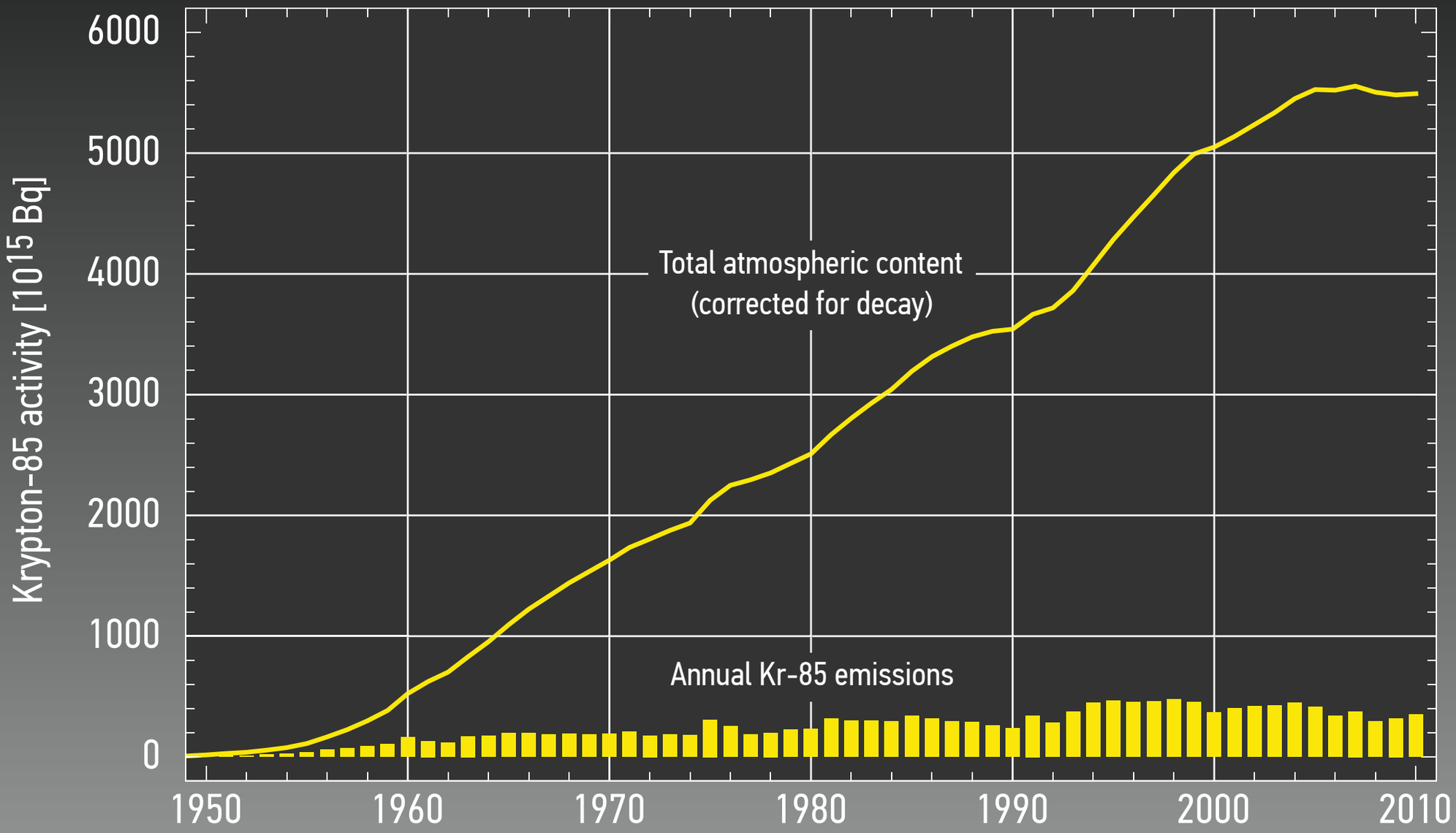
(Authors' estimates based on ORIGEN2/MCNP6 neutronics calculations)



M. Schöppner and A. Glaser, *Journal of Environmental Radioactivity,* 162–163, October 2016, pp. 300–309

CHARACTERIZING THE GLOBAL KRYPTON-85 BACKGROUND

PART 1: HISTORIC BASELINE

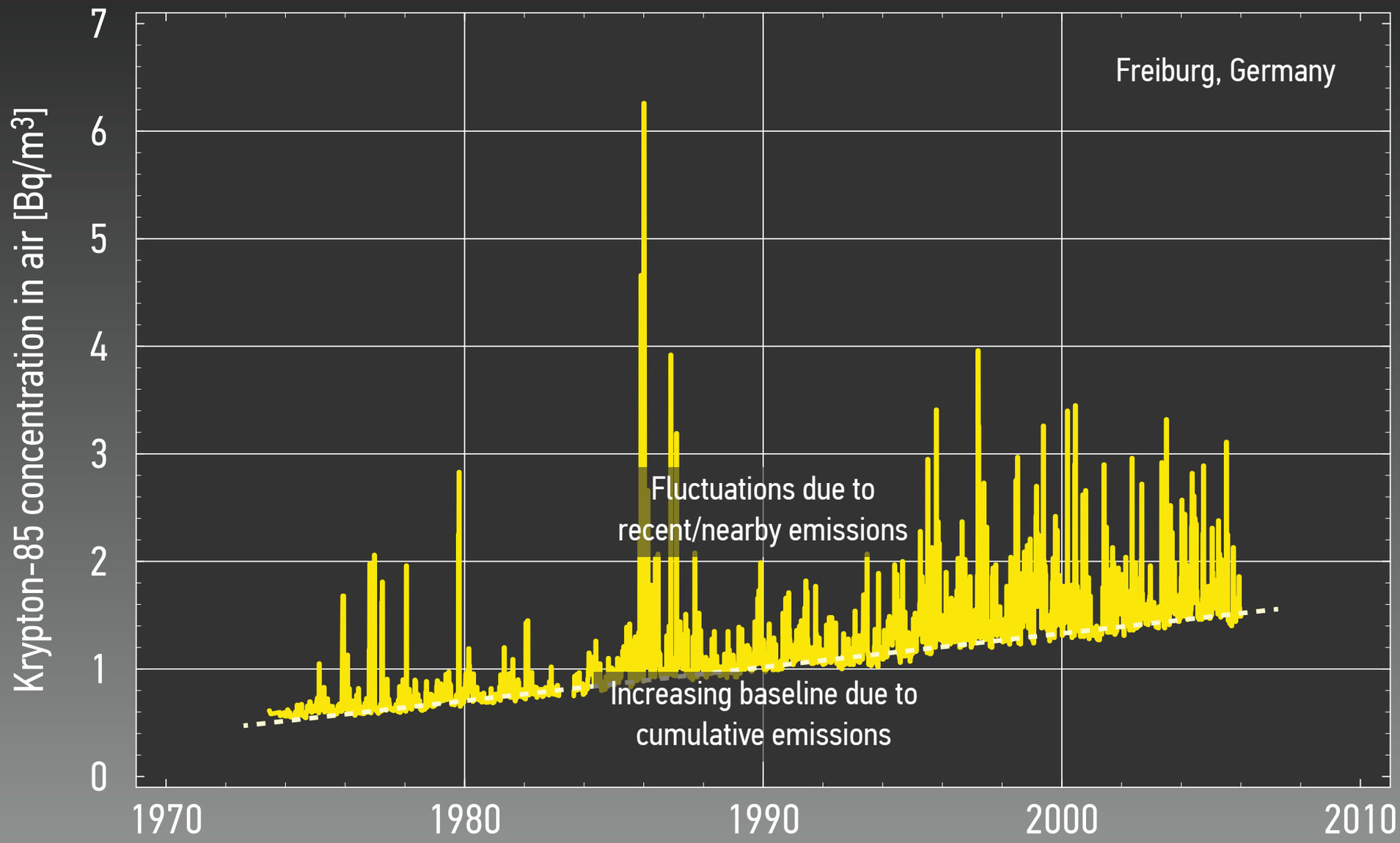


Background in 2010: ≈1.5 Bq/m³ in the Northern Hemisphere and ≈ 1.3 Bq/m³ in the Southern Hemisphere

M. Schöppner and A. Glaser, *Journal of Environmental Radioactivity,* 162–163, October 2016, pp. 300–309

CHARACTERIZING THE GLOBAL KRYPTON-85 BACKGROUND

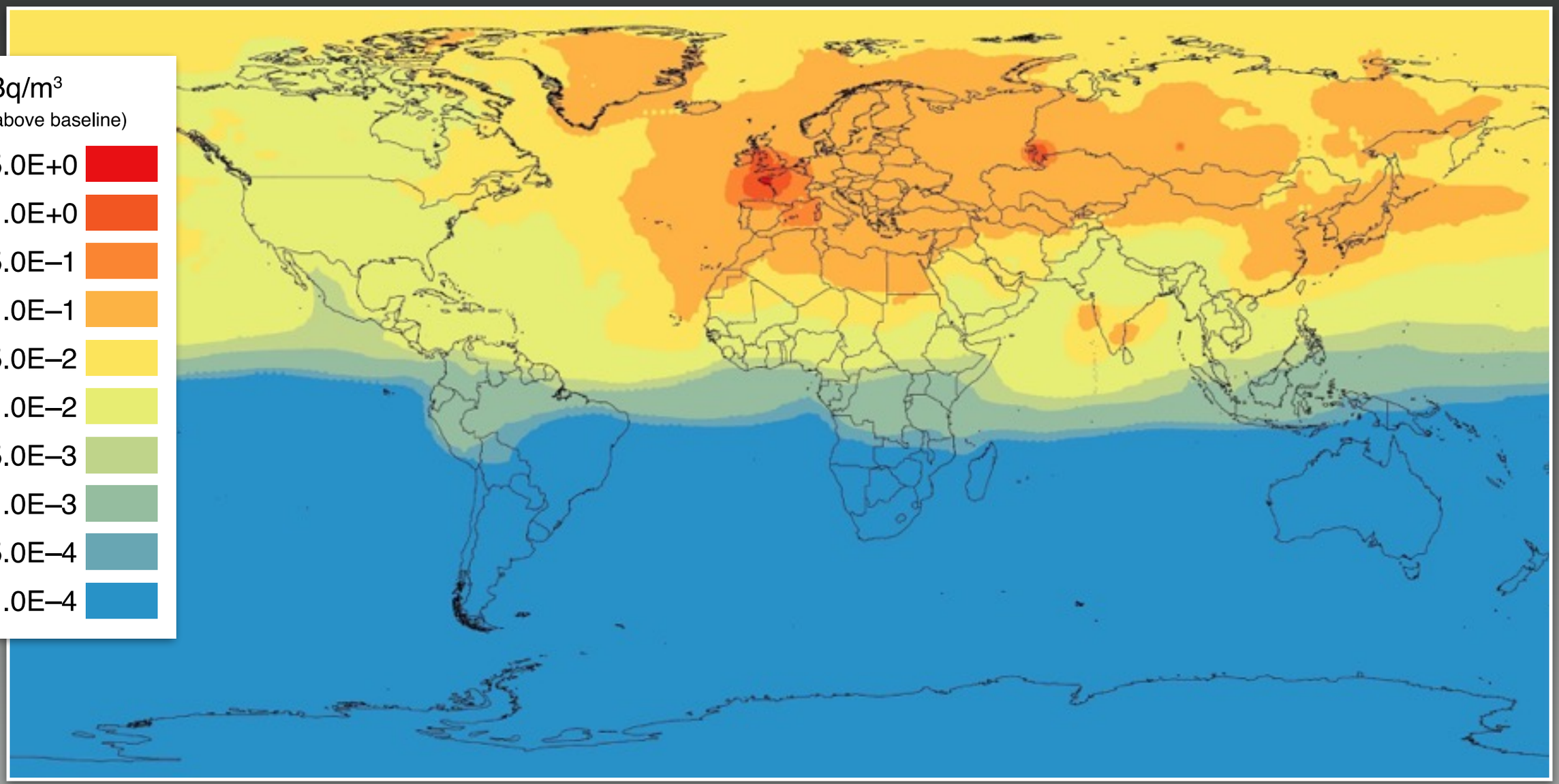
PART 2: ONGOING EMISSIONS



M. Schöppner and A. Glaser, *Journal of Environmental Radioactivity,* 162–163, October 2016, pp. 300–309

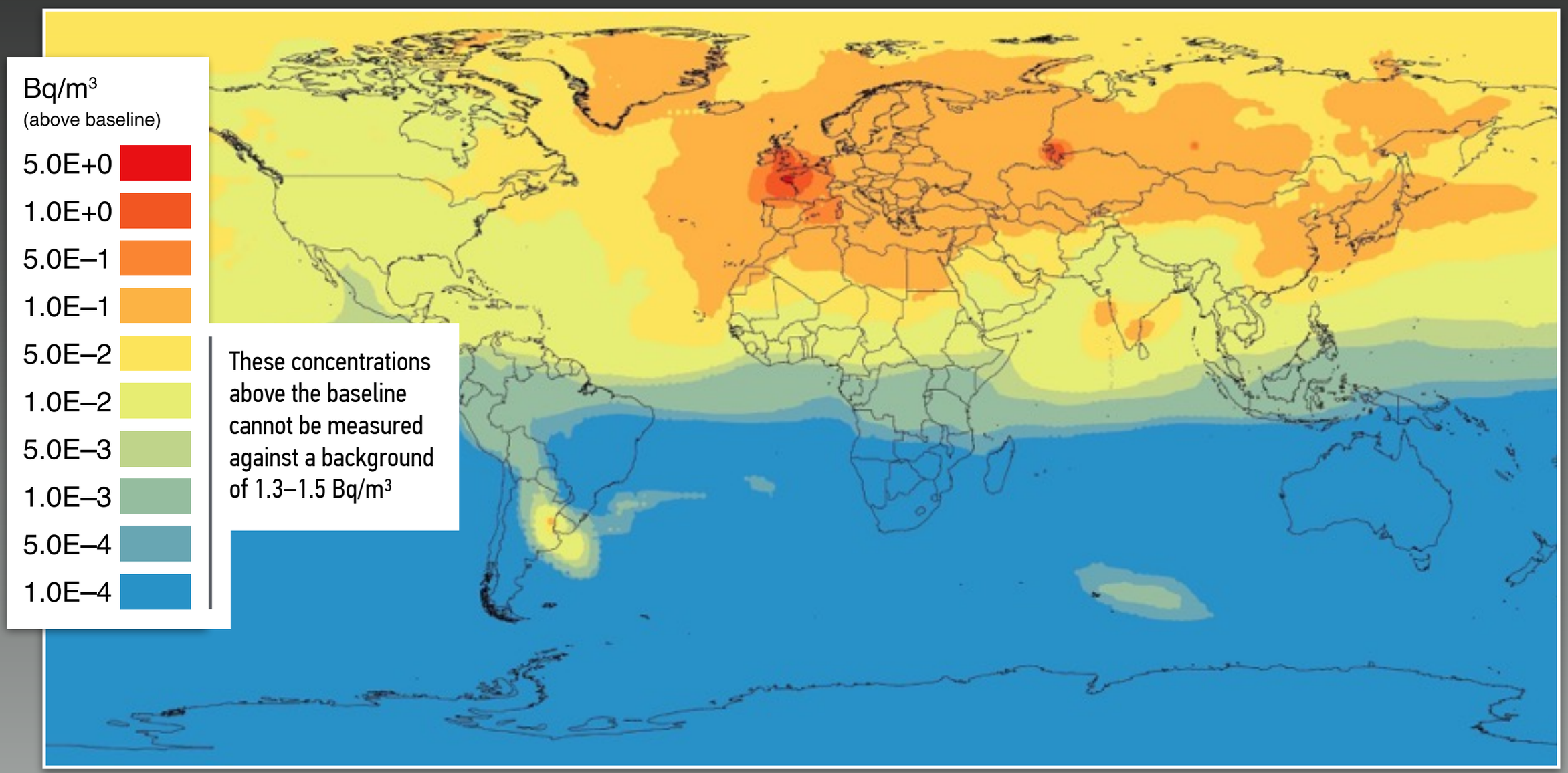
GLOBAL KRYPTON-85 VARIABILITY

$\mu_1 + \sigma_1 \approx 84\%$ OF LOCAL SAMPLES ARE WITHIN INDICATED UPPER CONCENTRATION LIMIT ABOVE (QUASI-CONSTANT) BASELINE μ_0



FICTIONAL PLANT IN SOUTH AMERICA SEPARATING 8 KG OF PLUTONIUM PER MONTH

BOTTOM LINE: GLOBAL KRYPTON MONITORING WOULD BE VERY HARD (TODAY)



IS REGIONAL KRYPTON-85 MONITORING A MORE VIABLE OPTION?

(FOR EXAMPLE, IN THE MIDDLE EAST)

A NUCLEAR WEAPON FREE ZONE IN THE MIDDLE EAST

EFFORTS TO ESTABLISH A NUCLEAR WEAPON FREE ZONE IN THE MIDDLE EAST

- Underway since 1974 (UN General Assembly Resolution)
- 1995 and 2010 NPT Review Conferences calling for establishment of the zone

CHALLENGES TO ESTABLISHING THE ZONE

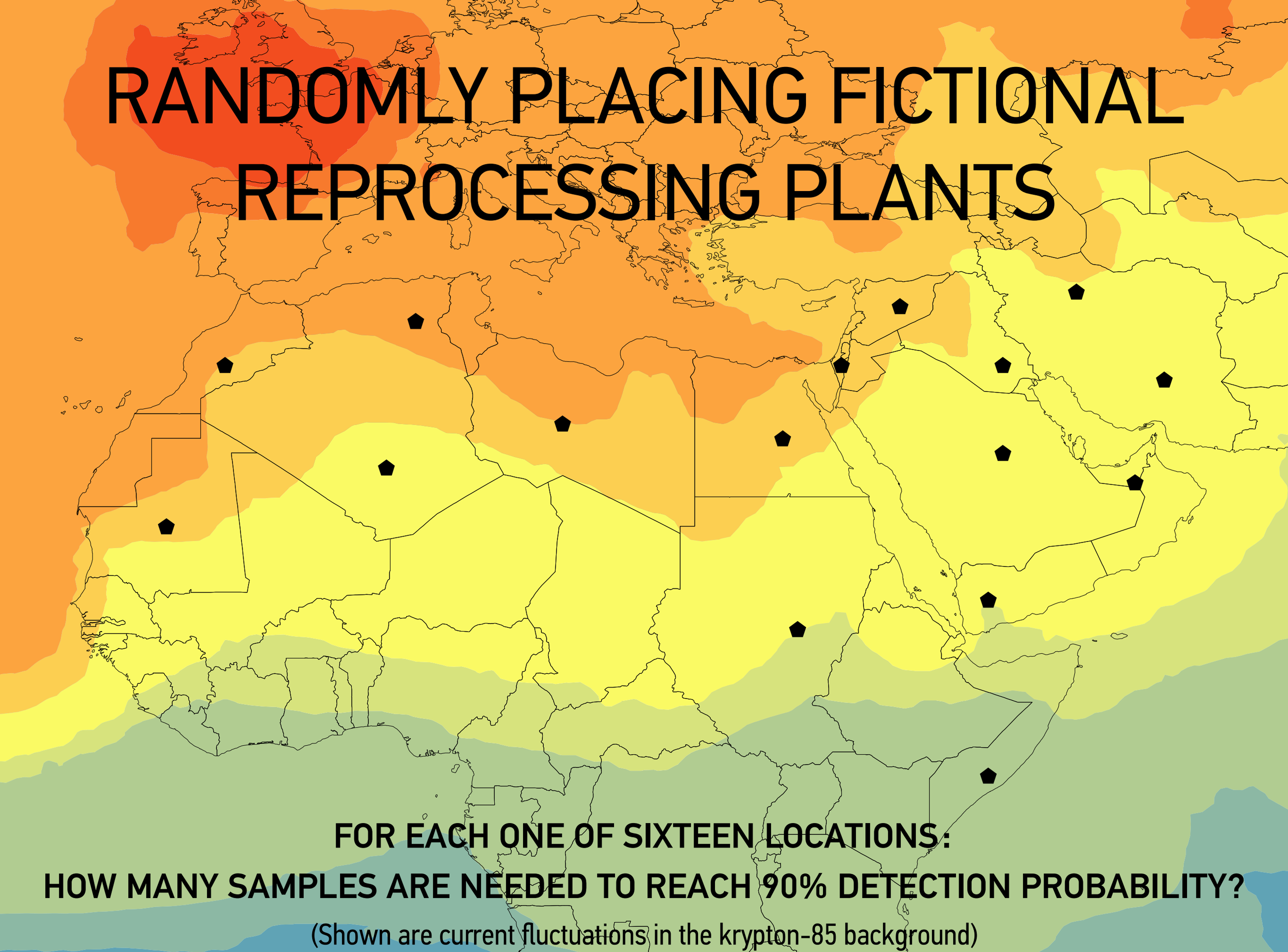
- History of covert proliferation efforts (and political turmoil) in the region
- Israel's nuclear weapons program and Iran's gas-centrifuge enrichment program

ROBUST VERIFICATION OF A ZONE IN THE MIDDLE EAST WOULD BE CRITICAL

- Deep mutual distrust among key countries
- Technical expertise is highly uneven; needs capacity-building in the area of verification

Source: www.bluesky-world.com (bottom)

RANDOMLY PLACING FICTIONAL REPROCESSING PLANTS

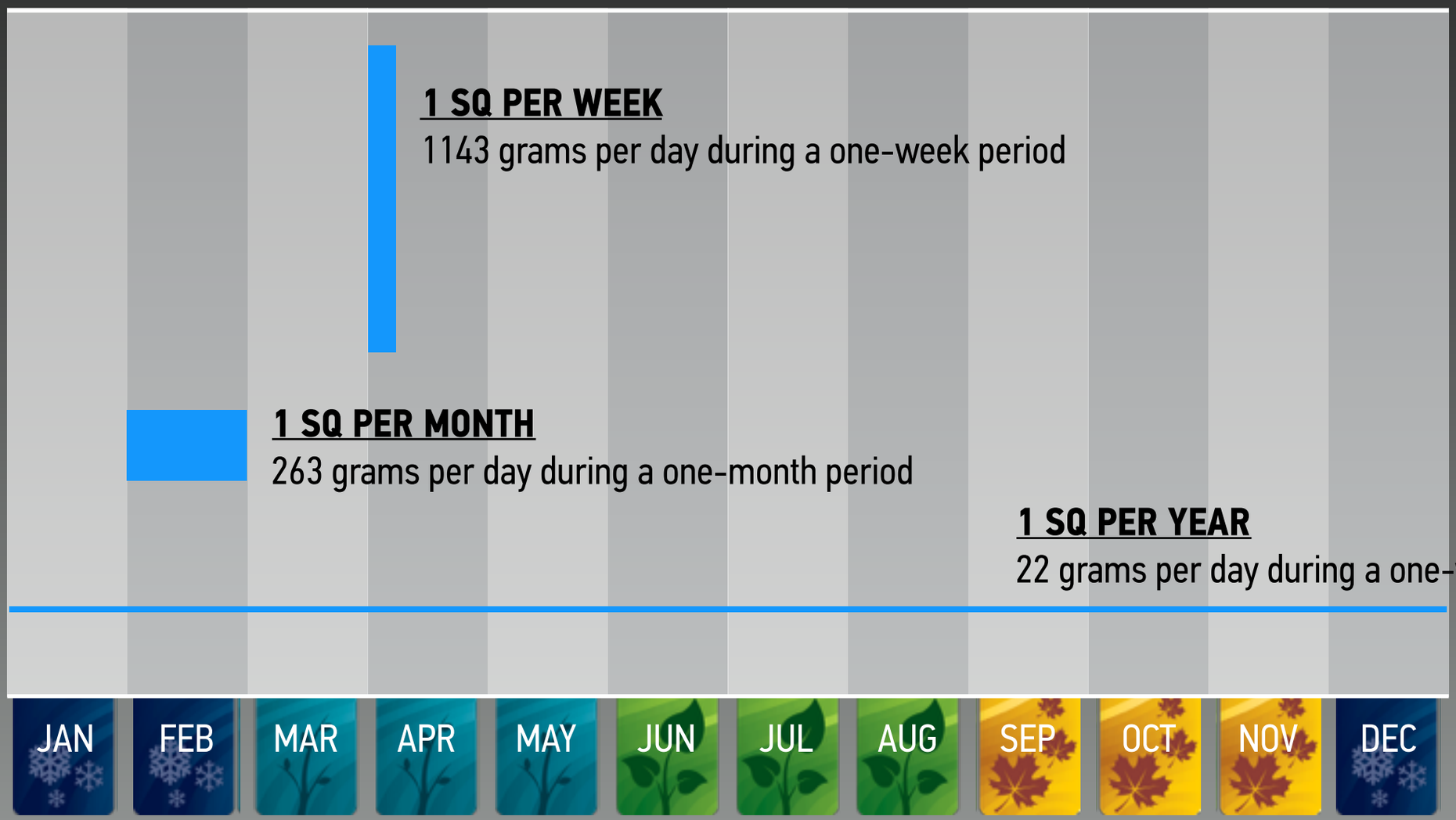


FOR EACH ONE OF SIXTEEN LOCATIONS:

HOW MANY SAMPLES ARE NEEDED TO REACH 90% DETECTION PROBABILITY?

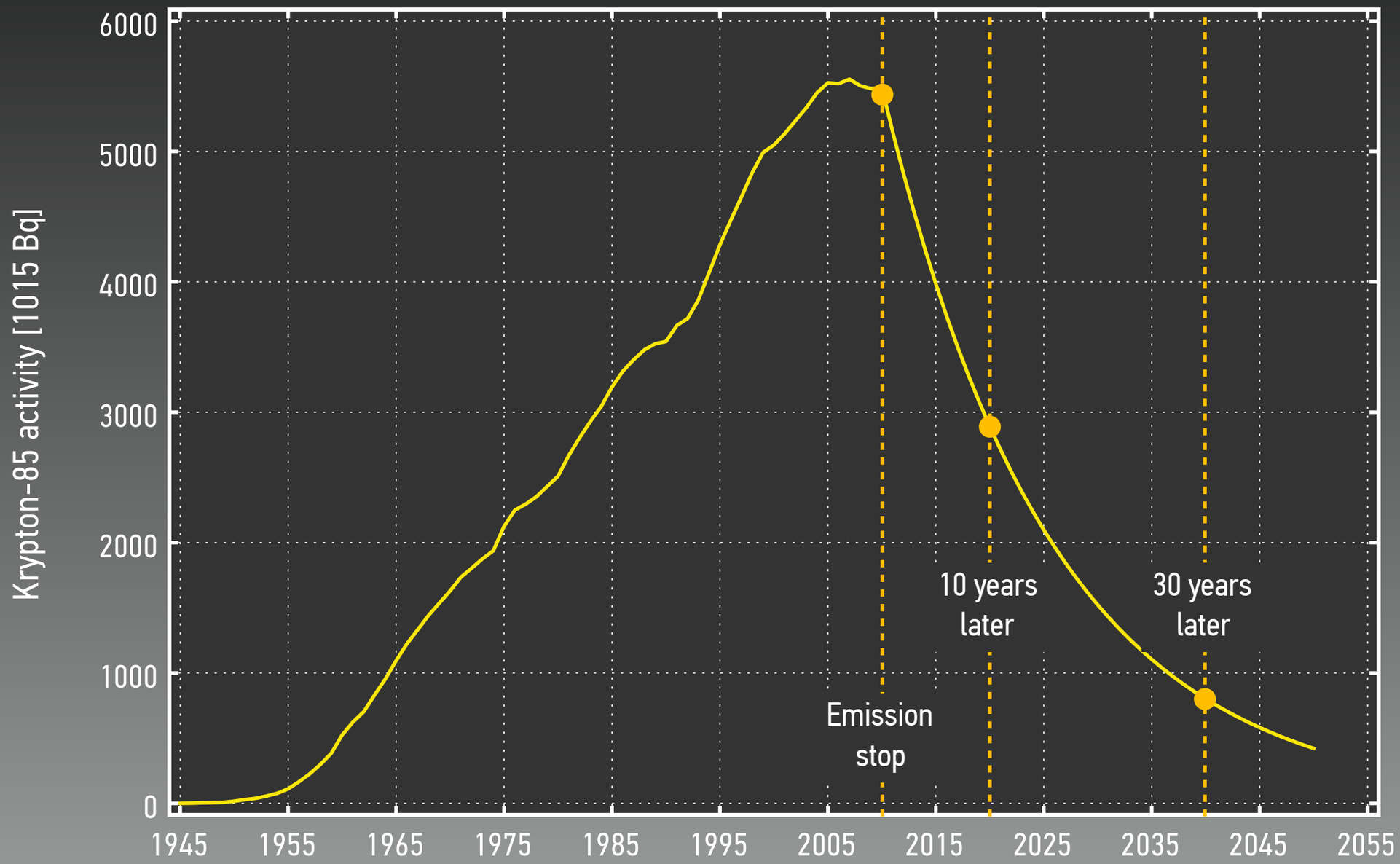
(Shown are current fluctuations in the krypton-85 background)

MAKING ONE SIGNIFICANT QUANTITY (8 KILOGRAMS) OF PLUTONIUM



Aaron Dulley, 6iee.com

POSSIBLE KRYPTON-85 FUTURES



(Once emissions stop, fluctuations in the background decay quickly)

HOW HARD IS IT TO DETECT CLANDESTINE PLUTONIUM SEPARATION?

WHEN COVERING THE ENTIRE MIDDLE EAST

NUMBER OF (RANDOM) SAMPLES NEEDED FOR 90% DETECTION PROBABILITY

Separation Rate	**1 SQ per year**	**1 SQ per month**	**1 SQ per week**
Days of repeated sampling	**365** days	**30** days	**7** days
Current emissions	**310** samples/day	**96** samples/day	**95** samples/day
Soon after emission stop	**190** samples/day	**77** samples/day	**79** samples/day
10 years after emission stop	**45** samples/day	**40** samples/day	**38** samples/day
30 years after emission stop	**9** samples/day	**10** samples/day	**9** samples/day

Based on Flexpart 8.2.3 simulations, 0.5° x 0.5° resolution (about 260,000 gridpoints)
Day-by-day emissions from all declared plants and one undeclared plant

HOW HARD IS IT TO DETECT CLANDESTINE PLUTONIUM SEPARATION?

WHEN COVERING ONLY THOSE COUNTRIES WITH NUCLEAR PROGRAMS/AMBITIONS

(Algeria, Egypt, Iran, Iraq, Israel, Jordan, Libya, Saudi Arabia, Syria, UAE; about 65% of region's landmass)

NUMBER OF (RANDOM) SAMPLES NEEDED FOR 90% DETECTION PROBABILITY

Separation Rate	1 SQ per year	1 SQ per month	1 SQ per week
Days of repeated sampling	365 days	30 days	7 days
Current emissions	150 samples/day	55 samples/day	51 samples/day
Soon after emission stop	95 samples/day	43 samples/day	42 samples/day
10 years after emission stop	25 samples/day	22 samples/day	21 samples/day
30 years after emission stop	6 samples/day	6 samples/day	5 samples/day

Based on Flexpart 8.2.3 simulations, 0.5° x 0.5° resolution (about 260,000 gridpoints)
Day-by-day emissions from all declared plants and one undeclared plant

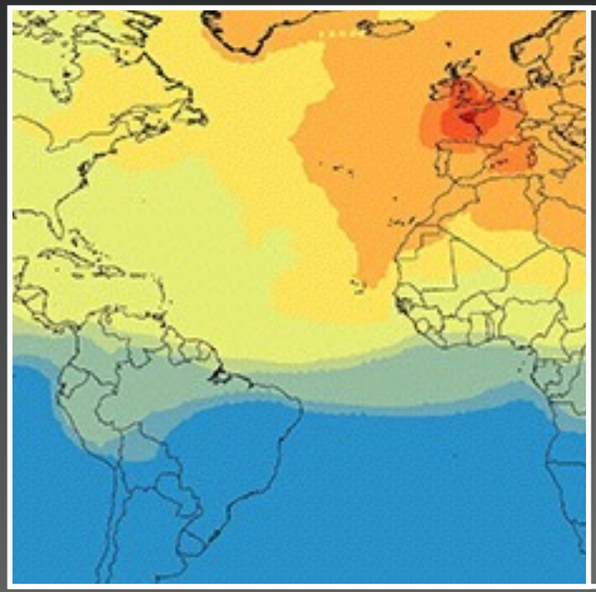
POSSIBLE VERIFICATION SYSTEM

Aircraft from Open Skies Treaty have a minimum range of 1,500 km
(but not a single country in the region is currently party to the treaty)

Few airports would be sufficient to support collection
Samples could be analyzed in regional labs and/or one central laboratory

SUMMARY

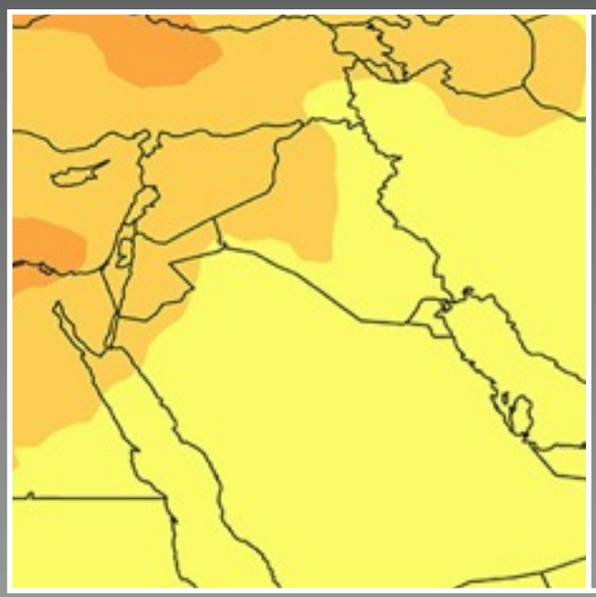
REGIONAL KRYPTON MONITORING: A VIABLE OPTION?



GLOBAL KRYPTON MONITORING IS CURRENTLY IMPRACTICAL

- Northern Hemisphere: Detectability of clandestine facilities inhibited by variability of background due to ongoing emissions from existing reprocessing plants (not only in Europe)
- On the order of 1000 samples/day required

Note: this is lower than the numbers presented at INMM last year



REGIONAL KRYPTON MONITORING IN THE MIDDLE EAST

- 50–150 daily samples could be sufficient today (max. 300)
- Number could drop to 10–20 samples per day if krypton emissions (from large commercial reprocessing plants) stopped
- Verifying the absence of reprocessing activities could be an important building block for confidence-building in the region

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