

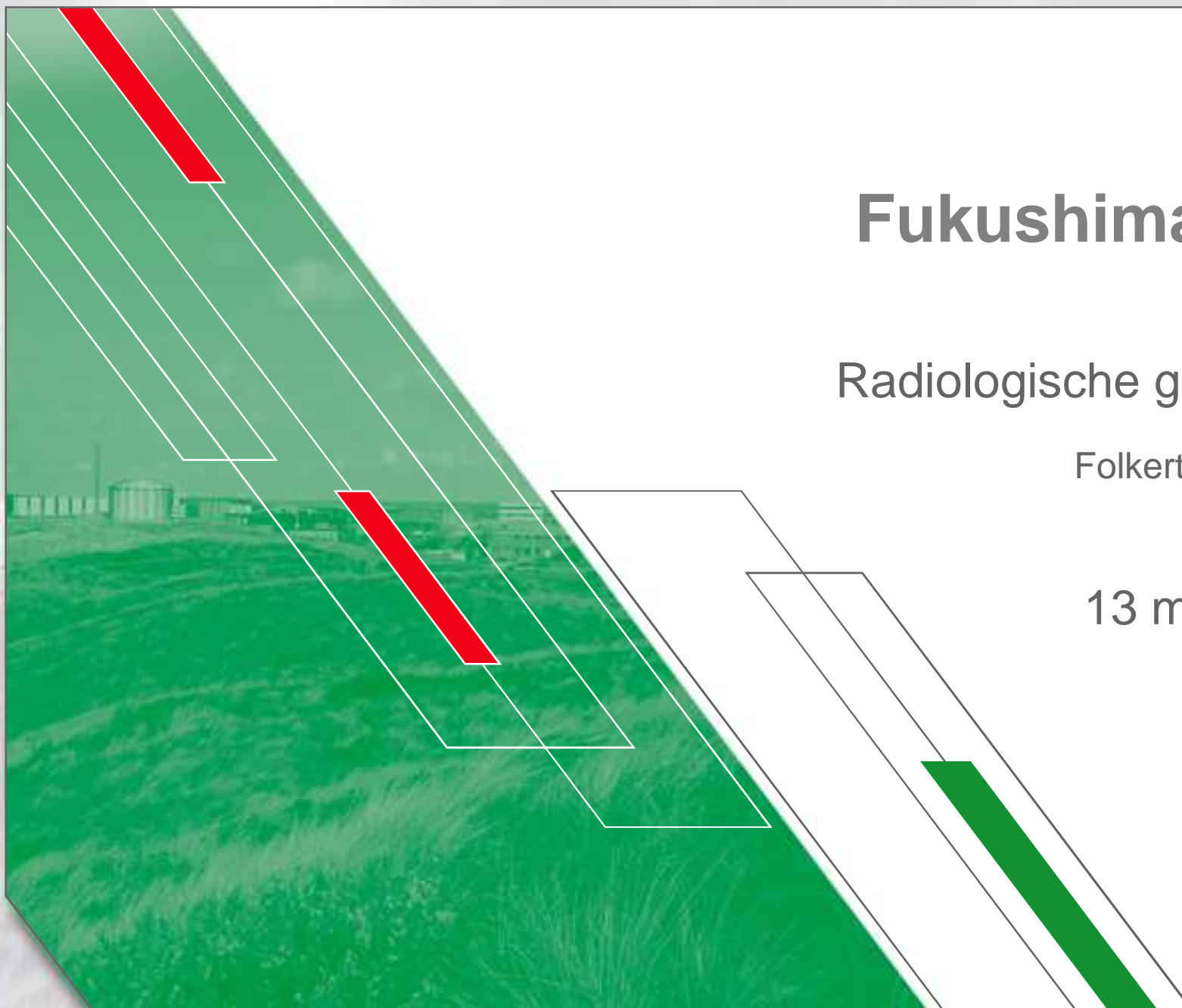


Fukushima 3/11

Radiologische gevolgen

Folkert Draaisma

13 mei 2011



Onderwerpen



- Vrijzetting
- Maatregelen
- Dosis- en dosistempo
 - Uitwendige bestraling
 - Inwendige 'besmetting'
 - Directe of deterministische effecten
 - Stochastische effecten
- Besmetting
- Werkers
- Bevolking
- Milieu

- Acute stralingsziekte
- Huid- en longschade

- Schildklierkanker
- Leukemie
- 'genetische' effecten



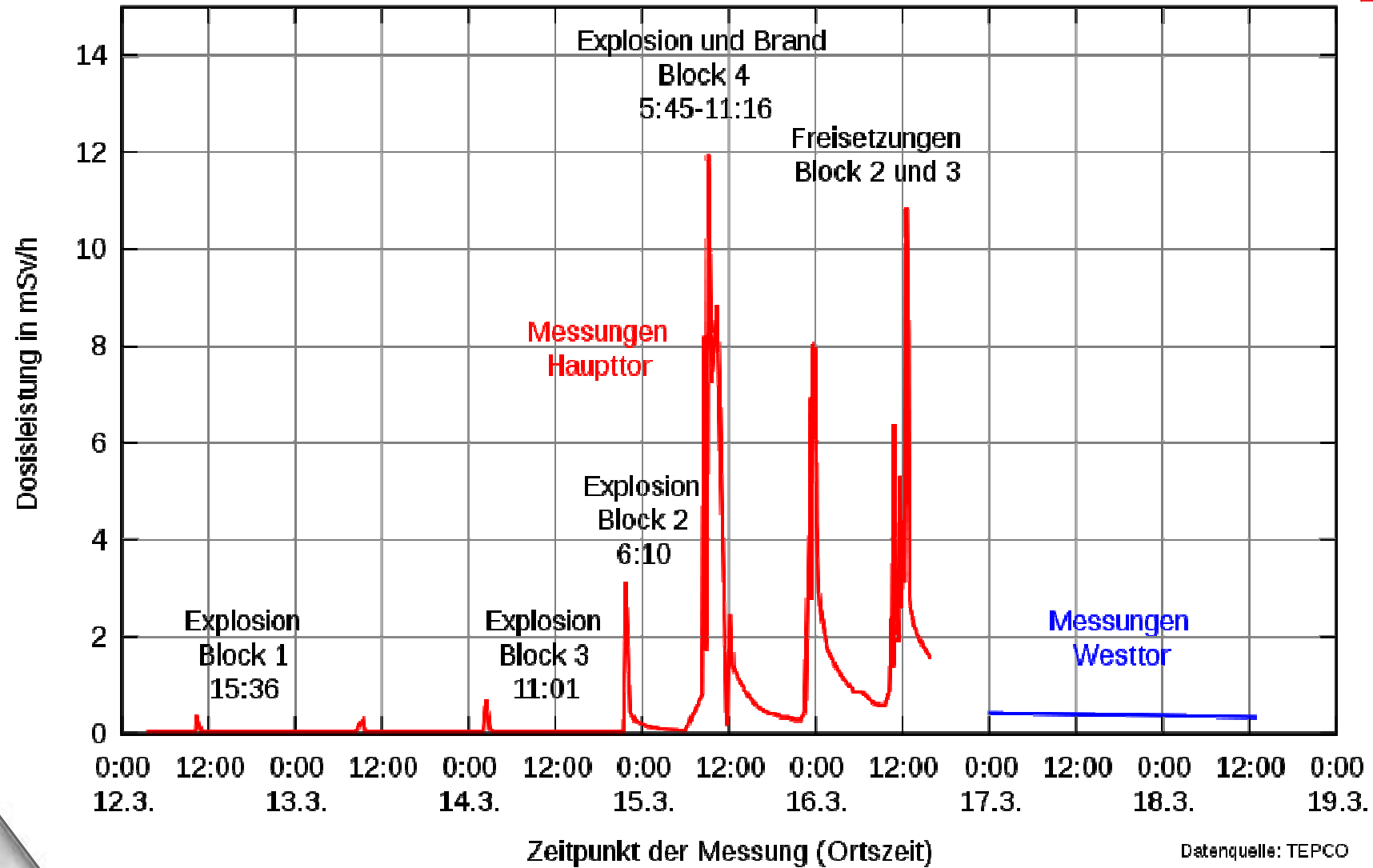
Soorten dosislimiteringen



- Reguliere situaties – stochastisch
 - *Dosislimiet werkers* → 20 mSv/j
 - *Dosislimiet bevolking* → 1 mSv/j
- Reguliere situaties werkers – deterministisch
 - *Extremiteiten* → 500 mSv/j
 - *Huid* → 500 mSv/j
 - *Ooglens* → 150 mSv/j
- Interventie
 - *Levensreddend handelen* → 750 mSv
 - *Belangen veilig stellen* → 250 mSv
 - *Hulpverlening* → 100 mSv



Emissies



Emissieschattingen



- **I-131: 130.000 TBq**
 - ca. 7% van Tsjernobyl emissie
- **Cs-137: 6.000 TBq**
 - ca. 7% van Tsjernobyl emissie
- < 1% lozing van totale activiteitsinventaris uit reactoren units #1, 2 en 3 + SF pools units #3 en 4:

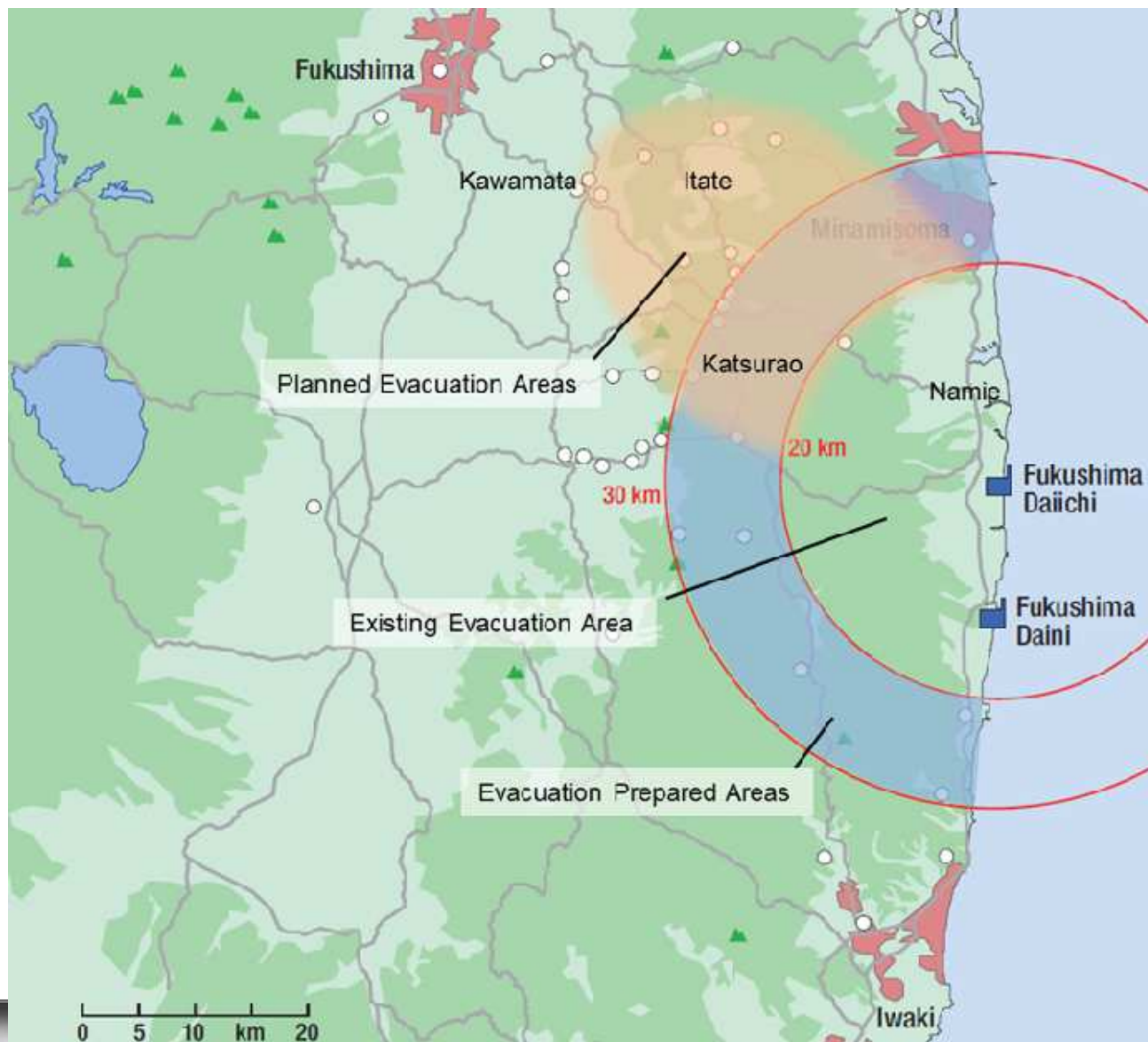
NPK Interventieniveaus



NPK interventieniveaus directe maatregelen

Maatregel	Tijd a)	E (mSv)	Hth (mSv) b)	Hrbm (mSv) c)	Hlo (mSv) d)	Hhu (mSv) e)
Preventieve evacuatie f, g)	24 h	1000	5000	1000	4000	3000
Evacuatie na pluimpassage g)	48 h 24 h	200 h)	1500		2000	
Jodiumprofylaxe kinderen i, j)	48 h		100 h)			
Jodiumprofylaxe volwassenen j, k)	48 h		1000 h)			
Schuilen	48 h 24 h	10 h)	50 – 500			
Huidontsmetting	24 h					50 l)
Huidontsmetting met medische controle	24 h					500 l)
Niet urgente evacuatie m)	1 jaar	50 – 250 m, n)				
Terugkeer	50 jaar o)	50 – 250				

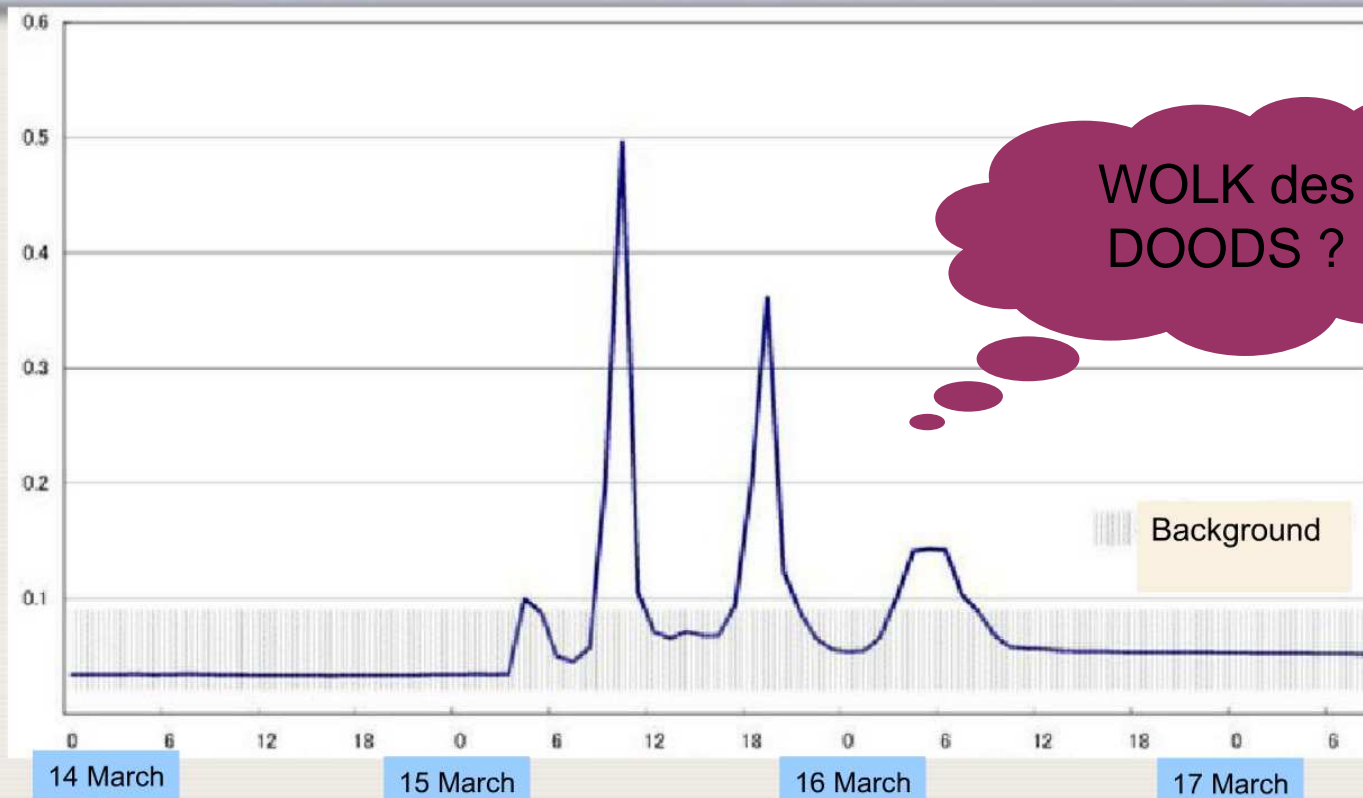
Evacuatie



Dosistempi en gebeurtenissen



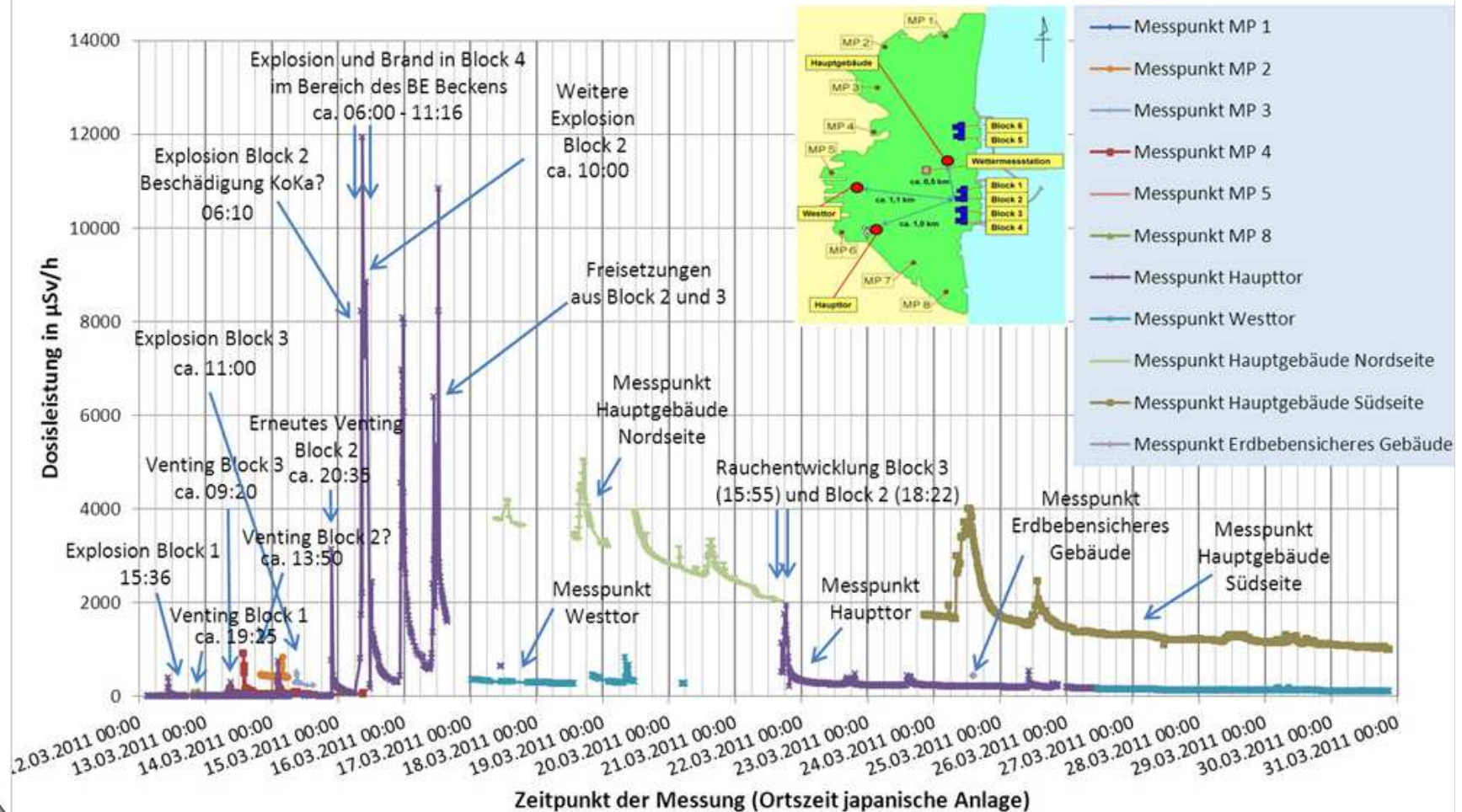
Gamma-dose rate at Tokyo, 230 km South West
(microSv/h)



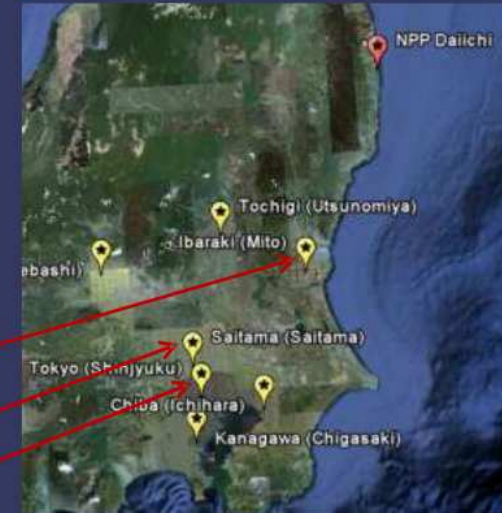
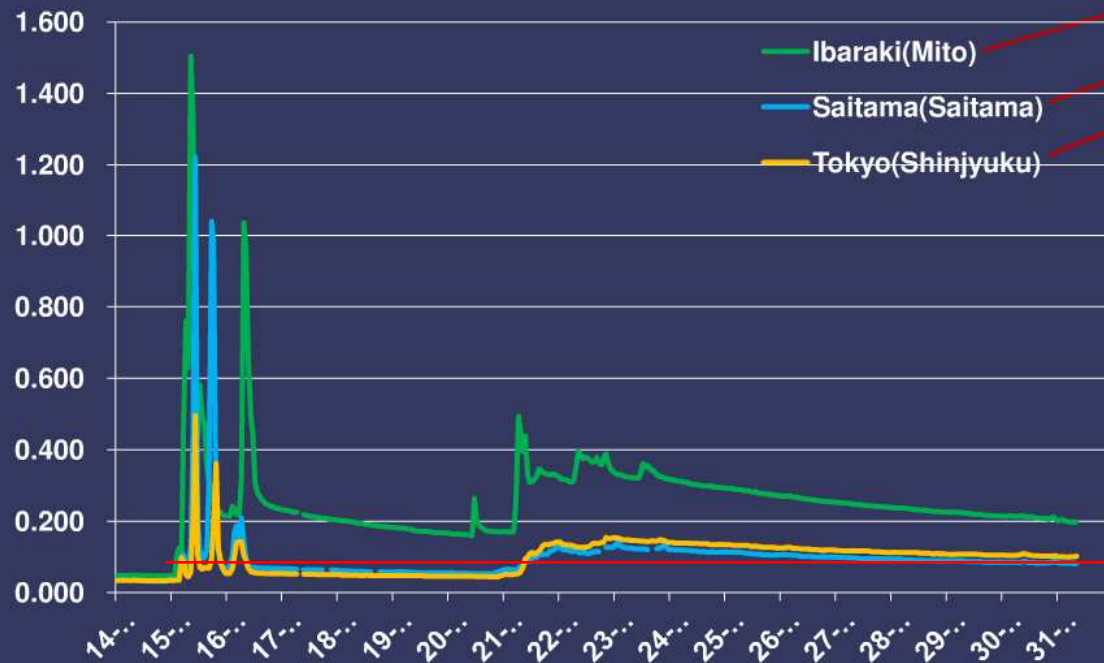
Dosistempen gebeurtenissen



Gemessene Dosisleistungen an ausgewählten Messpunkten
Fukushima Daiichi - Daten des Betreibers TEPCO



Gamma Dose Rates in $\mu\text{Sv}/\text{hour}$ 14-31 March

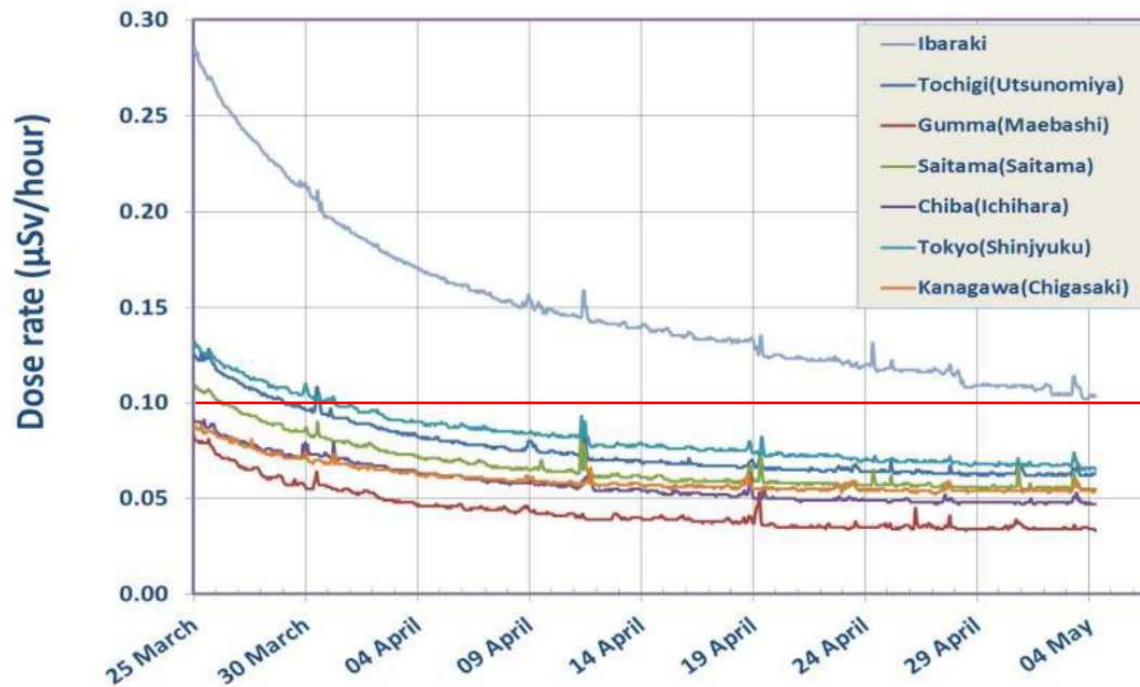


Natural Background: $0.1 \mu\text{Sv}/\text{hour}$: continue to decrease

Dosistempometingen



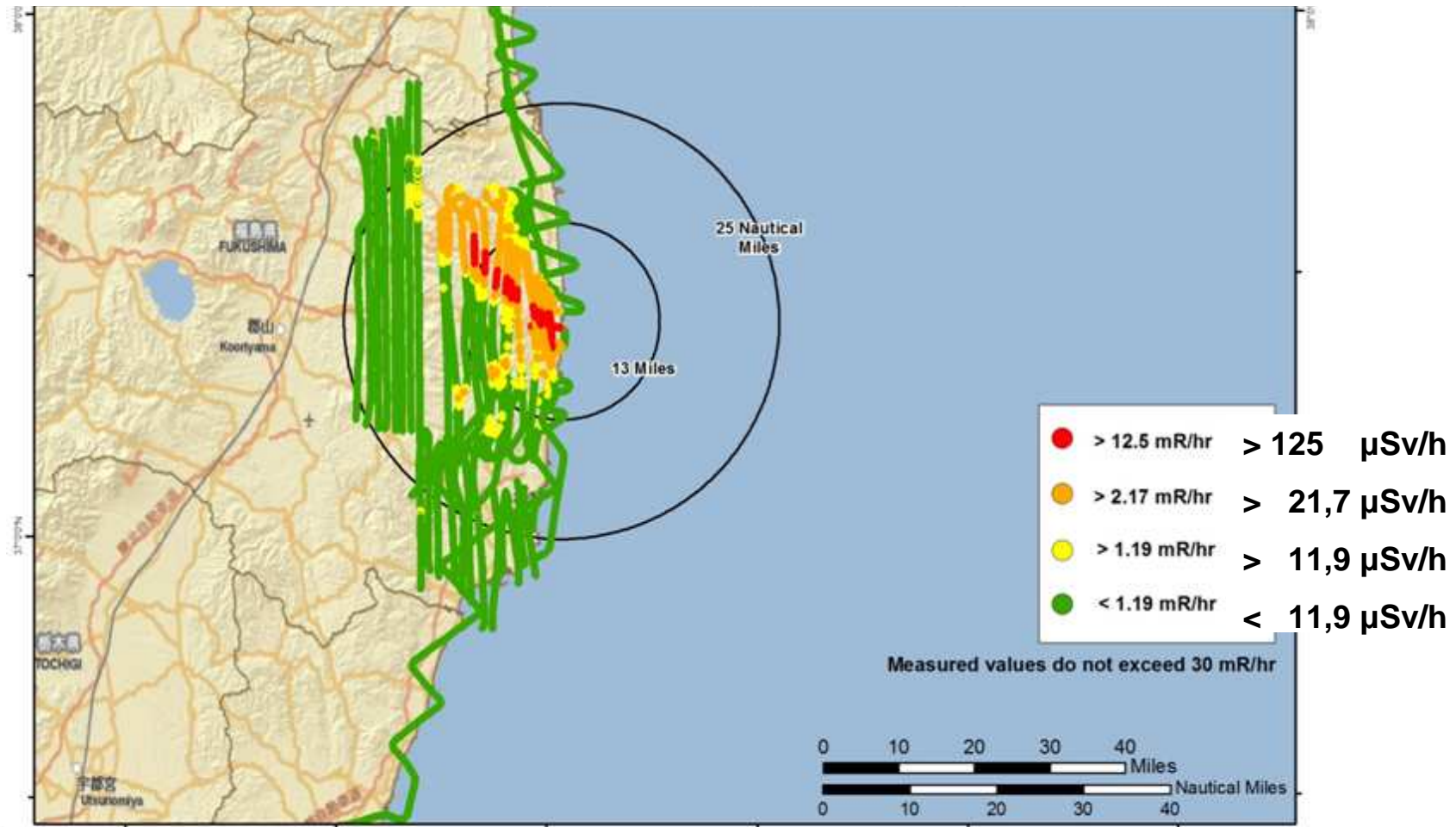
Gamma Dose Rates in 7 Prefectures 24 March – 4 May



Natural Background: $0.1 \mu\text{Sv/h}$

Aerial survey 17-19 Maart 2011

NW verspreiding



Map created on 03232011 0210 JST

Name: NIT_C-12_23Mar2011 v4

Nuclear Incident Team DOE NIT
Contact (202) 586 - 8100

Activiteitsmetingen op land



- **15 maart – Tokyo** (230 km ZZW van Fukushima)
(binnen waaien pluim vanuit oost, daarna weer terug)
 - dosistempo piek 0,8 – 1,5 $\mu\text{Sv/h}$
 - daggemiddelde $\sim 0,1 \mu\text{Sv/h}$ (normaal 0,05-0,1 $\mu\text{Sv/h}$)
- **23 maart – Tokyo** (230 km ZZW van Fukushima)
(regenbui)
 - I-131 100 – 175 Bq/l in drinkwater
- **25 maart Ibaraki** (65 km ZZW van Fukushima)
 - I-131 480 Bq/m², Cs-137 150 Bq/m²
- **28 maart Yamagata** (110 km NNW van Fukushima)
 - I-131 750 Bq/m², Cs-137 1200 Bq/m²
- **30 maart – Iitate** (40 km NW van Fukushima)
 - I-131 piekmeting 2 MBq/m², boven interventieniveau voor evacuatie (IAEA)

Interventieniveaus drinkwater/grazen



Interventieniveaus voor drinkwater

	Drinkwater (Bq/l)
Strontium-isotopen m.n. Sr-89 en Sr-90	125
Jodium-isotopen m.n. I-131	500
Alfa stralers m.n. Pu-239 en Am-241	20
Radionucliden met T-1/2 > 10 dagen m.n. Cs-134 en Cs-137	1000

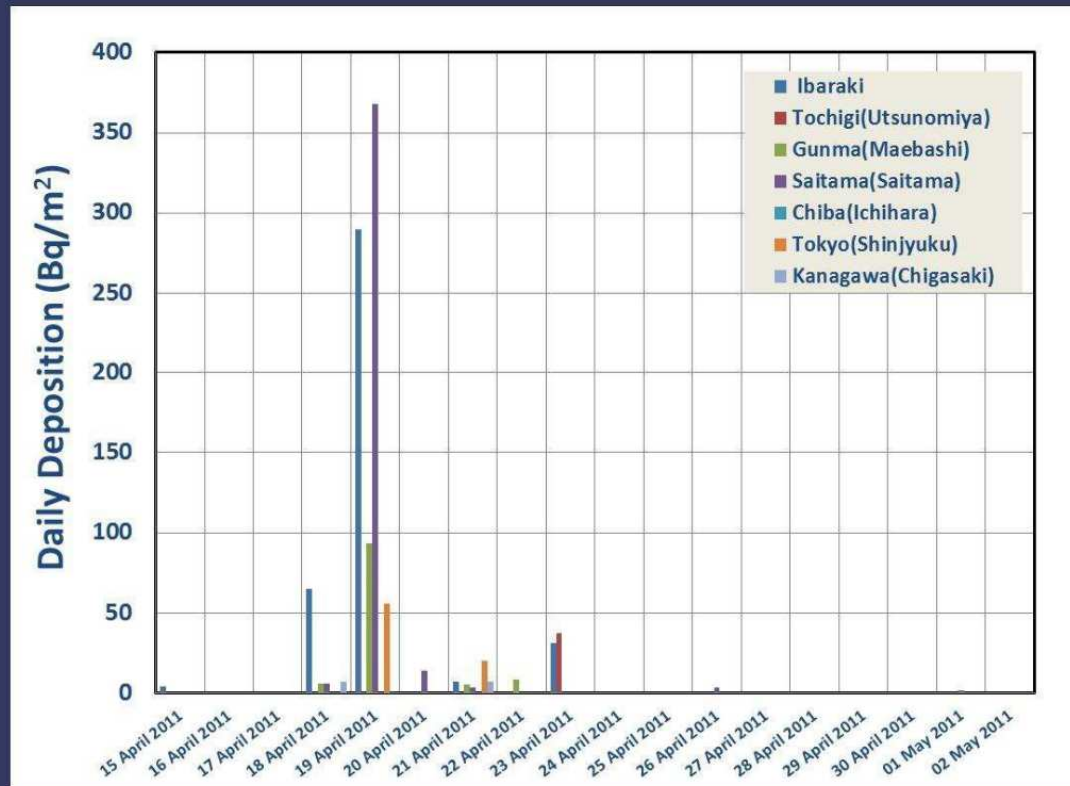
Afgeleid interventieniveau voor een graasverbod.

Nuclide	Bodembesmetting (Bq/m ²)
I-131	5000

I-131 depositie



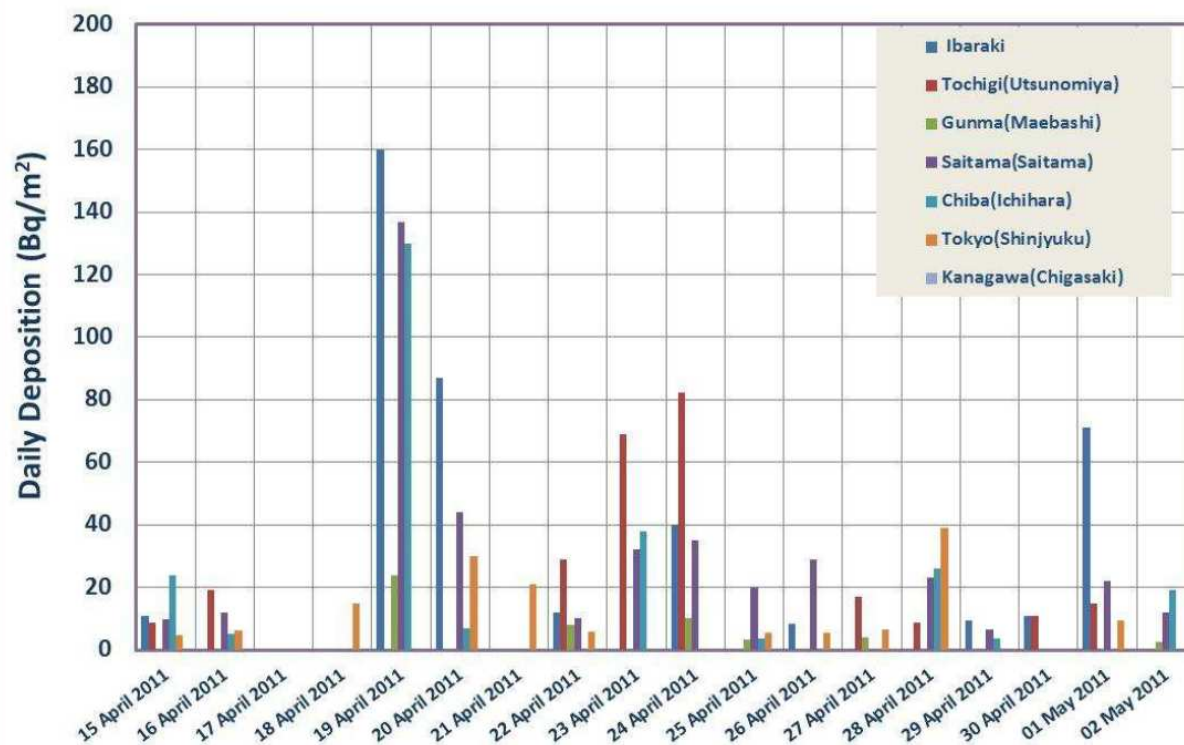
I-131 daily deposition (Bq/m^2)
15 April-2 May



Cs-137 depositie



Cs-137 daily deposition (Bq /m²) 15 April-2 May



Activiteitsmetingen in voedingsmiddelen

- **21 maart – Kitaibaraki** (75 km Z van Fukushima)
 - I-131 24.000 Bq/kg in spinazie
 - Cs-137 670 Bq/kg
- **Ibaraki, Totigi, Gunma, Fukushima** (prefecturen):
 - 21 maart – Spinazie en melk uit de handel
 - 23 maart – Kool en bloemkool uit de handel
- **Chiba, Ibaraki, Tochigi** (prefecturen):
 - 24 maart – Selderij, kool, spinazie uit de handel

Interventieniveaus voedsel



Interventieniveaus voor voedselbeperking

(Bq/kg of Bq/l)

Radionuclidengroep	Babyvoeding a)	Verse melk prod. b) c)	Minder belangrijke levensm. d)	Andere behalve minder belangrijke levensm. d)	Vloeibare levensm. e)	Diervoeders
Strontium-isotopen m.n. Sr-89 en Sr-90	75	125	7500	750	125	-
Jodium-isotopen			20000			
m.n. I-131	150	500	800	2000	500	-
Alfastraling emitterende isotopen m.n. Pu-239 en Am-241	1	20	12500	80	20	-
Alle andere nucliden met T-1/2 meer dan 10 dagen m.n. Cs-134 en Cs-137 f)	400	1000		1250	1000	125-5000 g)

Marine discharges due to leaking cable pit at Unit 2

In a news release issued on 25 April, NISA has communicated their evaluation of a report submitted by TEPCO on April 21 in relation to water containing radionuclides with high activity that flowed out from Unit 2 of Fukushima Daiichi Nuclear Power Station.

The outflow rate is estimated to have been approximately 4.3 m³/h. Concentration values, estimated from measurements, are:

I-131:	5.4 GBq/L
Cs-134:	1.8 GBq/L
Cs-137:	1.8 GBq/L

leading to an estimated overall amount of total release of about
4.7 PBq (4.7 x 10¹⁵ Bq)

Verspreiding in en over zee

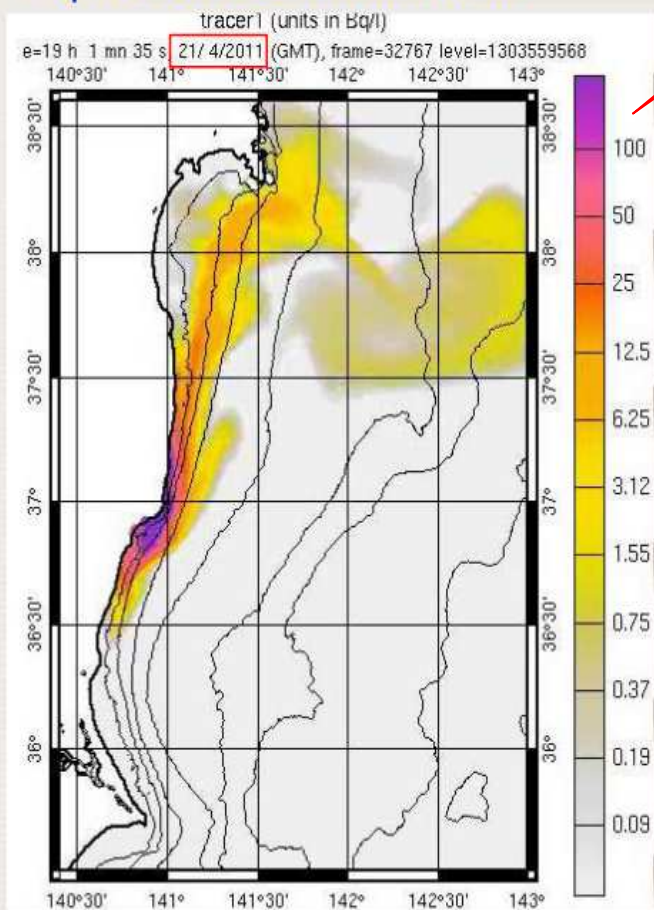
Bq/l



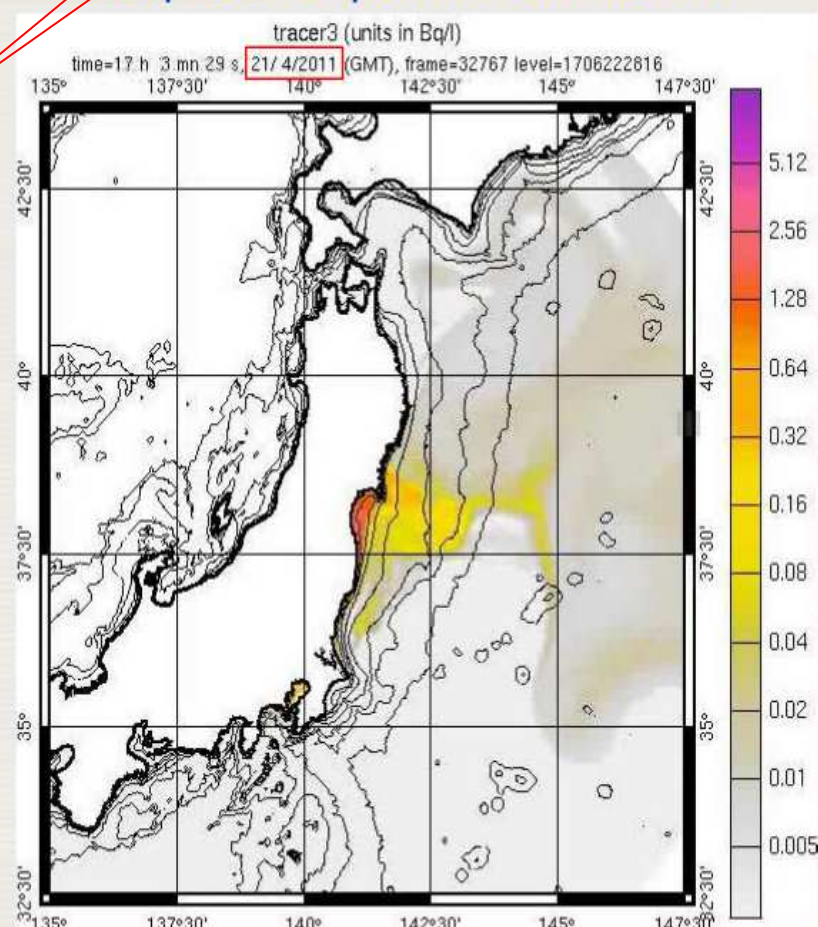
sirocco tracer1 (units in Bq/l)
25/ 3/2011 (GMT), frame=0 level=744780832

sirocco

Liquid release simulation



Atmospheric deposition simulation



Activiteitsmetingen in zee



330 m zuid van uitlaat

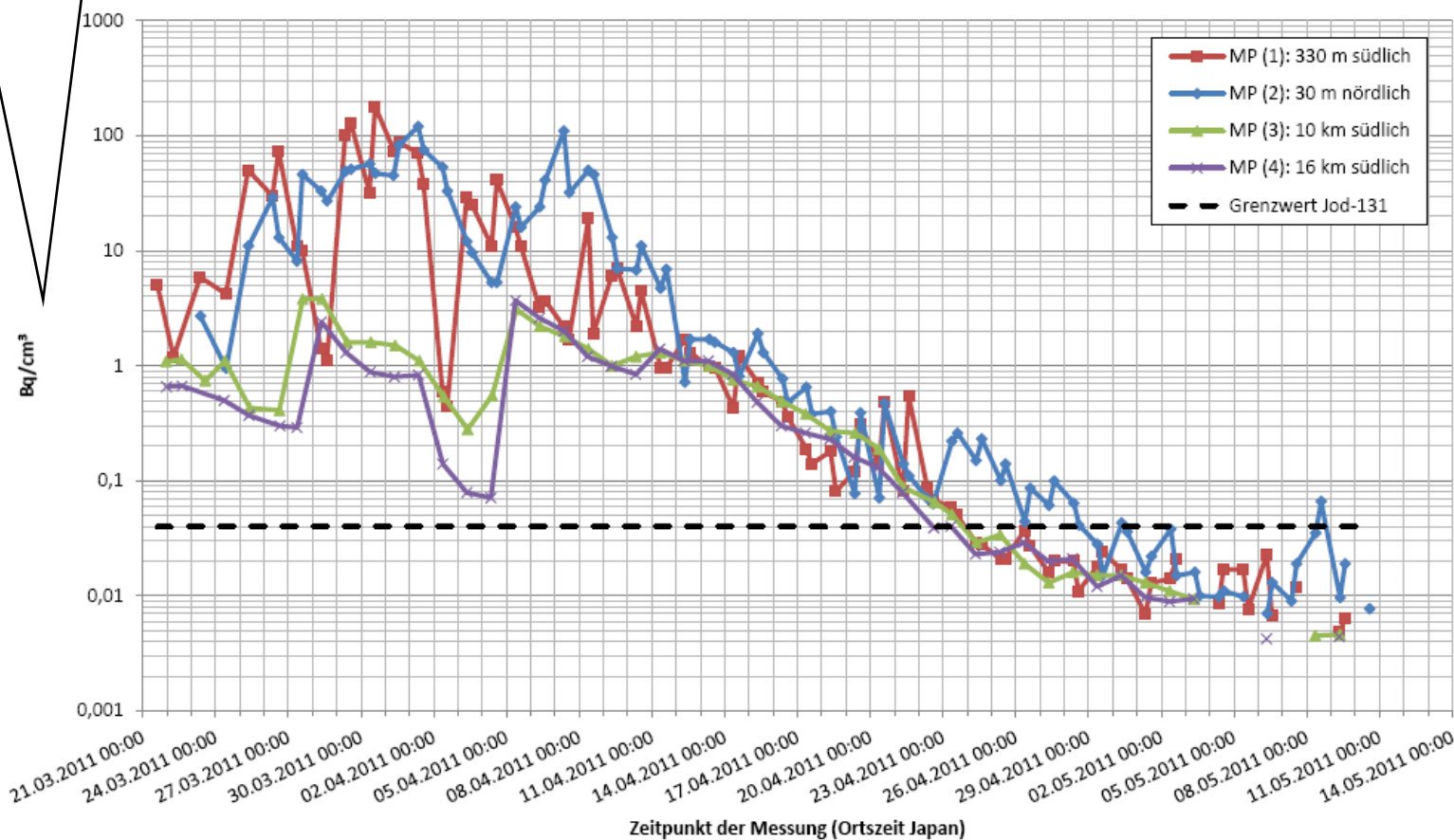
- **23/24 maart**
 - I-131 80 MBq/m³, Cs-137 26 MBq/m³
- **26 maart**
 - I-131 50 MBq/m³, Cs-137 7 MBq/m³
- **29 maart**
 - I-131 138 MBq/m³, Cs-137 32 MBq/m³
 - Cs-134 31 MBq/m³, Cs-136 2,8 MBq/m³
- **30 maart**
 - I-131 180 MBq/m³

Activiteitsmetingen in zee



kBq/l
MBq/m³

Kontamination Seewasser mit Jod-131
Daten des Betreibers TEPCO



Effecten op zeeleven



- Verdunning door zeestroming - Accumulatie in voedselketen
- Effecten: ziekte, sterfte, voortplanting (grootste gevoeligheid)
- Zeewier
 - Accumulatie I-131
 - Effecten op groei bij honderden mGy/dag – 1 Gy/dag
- Schaaldieren
 - Geen effect op groei bij 1 Gy/dag
- Vissen:
 - LD₅₀ kan oplopen tot tientallen Gy
 - geen effect op voortplanting bij enkele – tientallen mGy/dag
→ bij tientallen – honderden MBq/kg vis

Deterministische effecten



On-Site 3 exposed workers medical status

March 24

3 workers exposed to radiation (2 with feet/legs contamination)

NIRS Hospital

Radiation monitoring:

Body dosimeter: 173, 179, 180 mSv

(Dose limit for emergency workers in life saving operation: 250 mSv)

Medical condition

Transient redness (suggested a dose between 2000-3000 mSv locally)

Under medical observation for 4 days.

Latest news:

All 3 patients were discharged (March 28 at 12:00 Tokyo time)

2 patients with local legs problems: Regular medical follow-up

Monitoring of public and workers

- As of April 27: 175045 people had been screened (NISA)
- Internal+ External doses received by emergency workers until the end of March 2011 (TEPCO):
 - 2 workers: 200-250 mSv.
 - 8 workers: 150-200 mSv
 - 11 workers: 100-150 mSv.
 - Other workers: below 100 mSv.

INES 7

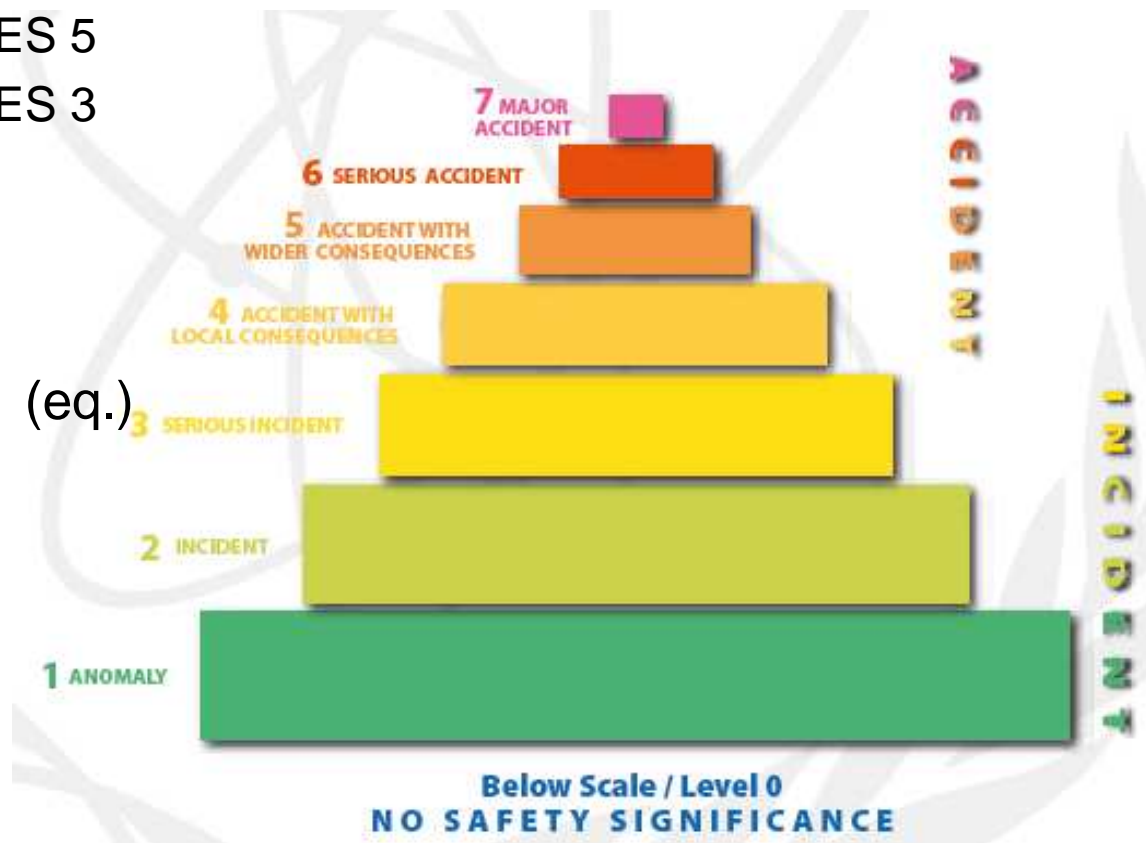


1e inschaling Fukushima:

- Units 1-3 : INES 5
- Unit 4 : INES 3

2e inschaling

- Alle units samen
- > 50.000 TBq I-131 (eq.)
- INES 7

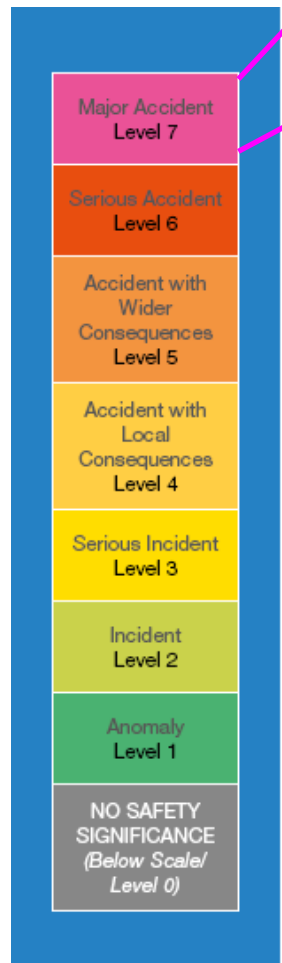


INES-schaal



7

Chernobyl, 1986 — Widespread health and environmental effects. External release of a significant fraction of reactor core inventory.



INES classifies nuclear and radiological accidents and incidents by considering three areas of impact:

People and the Environment considers the radiation doses to people close to the location of the event and the widespread, unplanned release of radioactive material from an installation.

Radiological Barriers and Control covers events without any direct impact on people or the environment and only applies inside major facilities. It covers unplanned high radiation levels and spread of significant quantities of radioactive materials confined within the installation.

Defence-in-Depth also covers events without any direct impact on people or the environment, but for which the range of measures put in place to prevent accidents did not function as intended.

Communicating Events

Nuclear and radiological events are promptly communicated by the INES Member States, otherwise a confused understanding of the

event may occur from media or from public speculation. In some situations, where not all the details of the event are known early on, a provisional rating may be issued. Later, a final rating is determined and any differences explained.

To facilitate international communications for events attracting wider interest, the IAEA maintains a web-based communications network that allows details of the event to immediately be made publicly available.

The two tables that follow show selected examples of historic events rated using the INES scale, ranging from a Level 1 anomaly to a Level 7 major accident; a much wider range of examples showing the rating methodology is provided in the INES Manual.

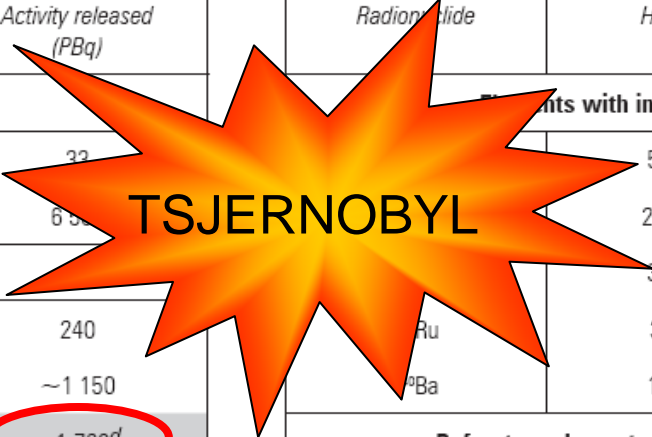
Scope of the Scale

INES applies to any event associated with the transport, storage and use of radioactive material and radiation sources, whether or not the event occurs at a facility. It covers a wide spectrum of practices, including industrial use

Vrijzetting ~ 12.000.000.000.000.000.000 Bq



Radionuclide	Half-life	Activity released (PBq)
Inert gases^a		
⁸⁵ Kr	10.72 a	32
¹³³ Xe	5.25 d	6.5
Volatile elements^a		
^{129m} Te	33.6 d	240
¹³² Te	3.26 d	~1 150
¹³¹ I	8.04 d	~1 760 ^d
¹³³ I	20.8 h	910
¹³⁴ Cs	2.06 a	~47 ^b
¹³⁵ Cs	13.1 d	36
¹³⁷ Cs	30.0 a	~85 ^e



Radionuclide	Half-life	Activity released (PBq)
Elements with intermediate volatility^a		
⁹⁰ Sr	50.5 d	~115
¹³⁷ Cs	29.12 a	~10
¹³⁸ La	99.3 d	>168
¹⁰⁶ Ru	368 d	>73
¹⁴⁰ Ba	12.7 d	240
Refractory elements (including fuel particles)^c		
⁹⁵ Zr	64.0 d	84
⁹⁹ Mo	2.75 d	>72
¹⁴¹ Ce	32.5 d	84
¹⁴⁴ Ce	284 d	~50
²³⁹ Np	2.35 d	400
²³⁸ Pu	87.74 a	0.015
²³⁹ Pu	24 065 a	0.013
²⁴⁰ Pu	6 537 a	0.018
²⁴¹ Pu	14.4 a	~2.6
²⁴² Pu	376 000 a	0.00004
²⁴² Cm	18.1 a	~0.4

^a From references [D11, U3].
^b Based on ¹³⁴Cs/¹³⁷Cs ratio 0.55 as of 26 April 1986 [M8].
^c Based on fuel particle release of 1.5% [K13].
^d For comparison, the global release of ¹³¹I from atmospheric nuclear weapon testing was 675,000 PBq [U3].
^e For comparison, the global release of ¹³⁷Cs from atmospheric nuclear weapon testing was 948 PBq [U3].

Rest van de wereld



- Radioactiviteit tot in Europa meetbaar – minieme hoeveelheden
- Wereldwijd: onrust, angst, zelfs paniek
- NL haven:
 - enkele containers licht ‘besmet’ (enkele tot tientallen Bq/cm²)
 - Verontreiniging meestal eenvoudig schoon te maken
- Gezondheidseffecten buiten Japan alleen theoretisch

Conclusie



“Dus het valt allemaal wel mee?”

NEE! Het valt zeker niet mee, maar...

- Geen stralingsziekte bij werkers
- Persoonsdoses werkers < 250 mSv
- Schildklierdoses bij kinderen waarschijnlijk belangrijk beperkt door evacuatie en andere maatregelen
- Maatschappelijke en sociale ontwrichting door aardbeving, tsunami en evacuatie en onzekerheid/angst over de gevolgen van bestraling en ‘besmetting’ → grote kans op PT **stress**
- Komende weken vaststellen ‘besmettingsgraad’ op land en activiteitsconcentraties in zeeleven → mogelijk aantal gebieden voor langere tijd niet voor menselijke activiteiten geschikt; economische gevolgen