



STUDIECENTRUM VOOR KERNENERGIE  
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

# Fast mapping of radioactive ground contamination from the air : a helicopter view

# Fast mapping of radioactive *ground* contamination *from the air* : a helicopter view

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# The purpose is to map radioactive contamination *on the ground*, from the air

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- On the ground
  - Not in the air ( e.g. no radioactive plume )
  - Not in water ( e.g. as result of effluents in the sea or in a lake )
- Could be the result of :
  - Nuclear accident ( Chernobyl, Fukushima, but also smaller )
  - Routine radioactive wasting ( liquid effluents, or through the air )
    - Nuclear Industry
    - NORM industry
    - Mining industry
  - Terrorist actions
- Large enough : suspect area order of 1 km<sup>2</sup> or (much) more

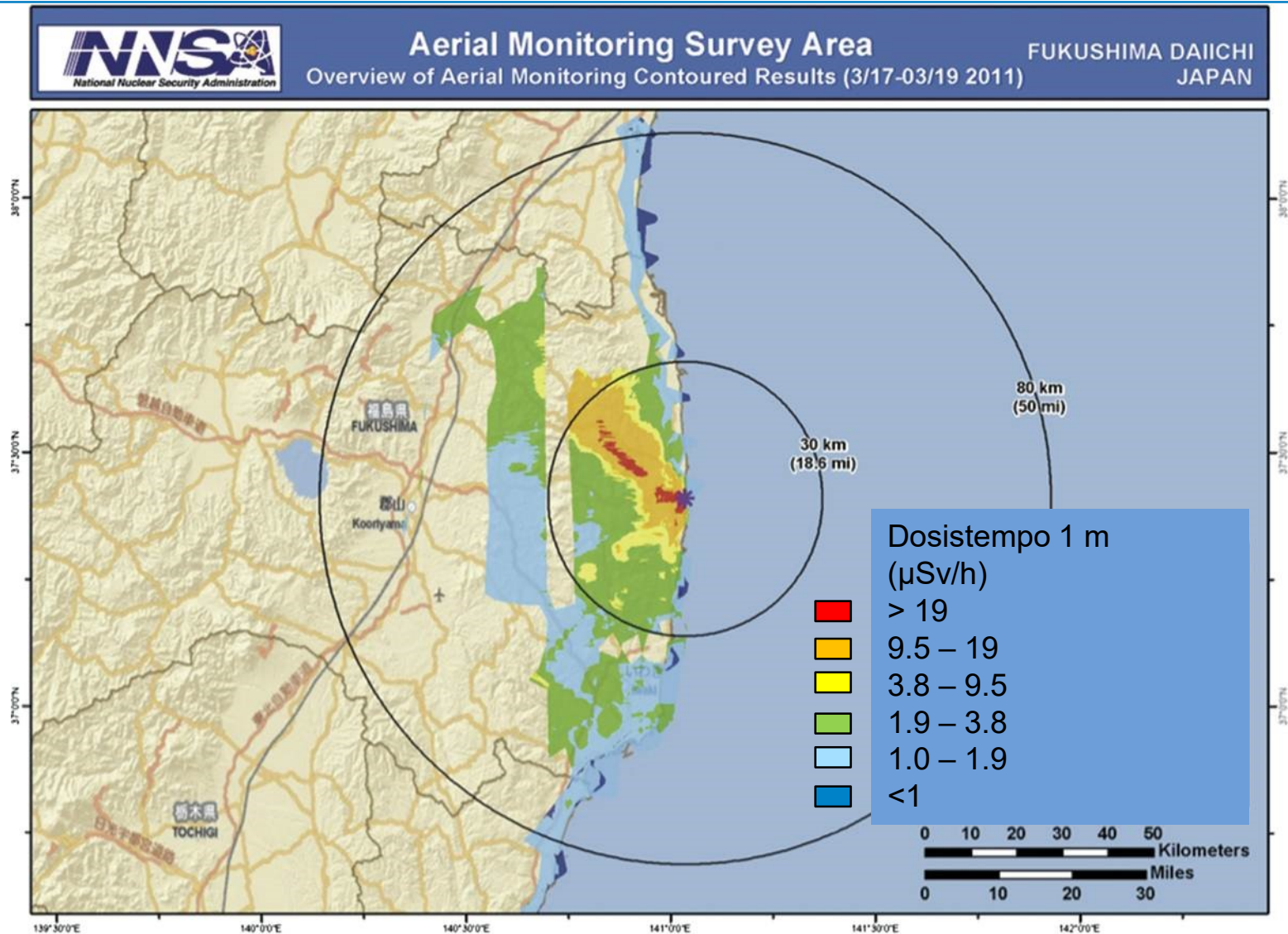
## Just a few figures and results from Fukushima

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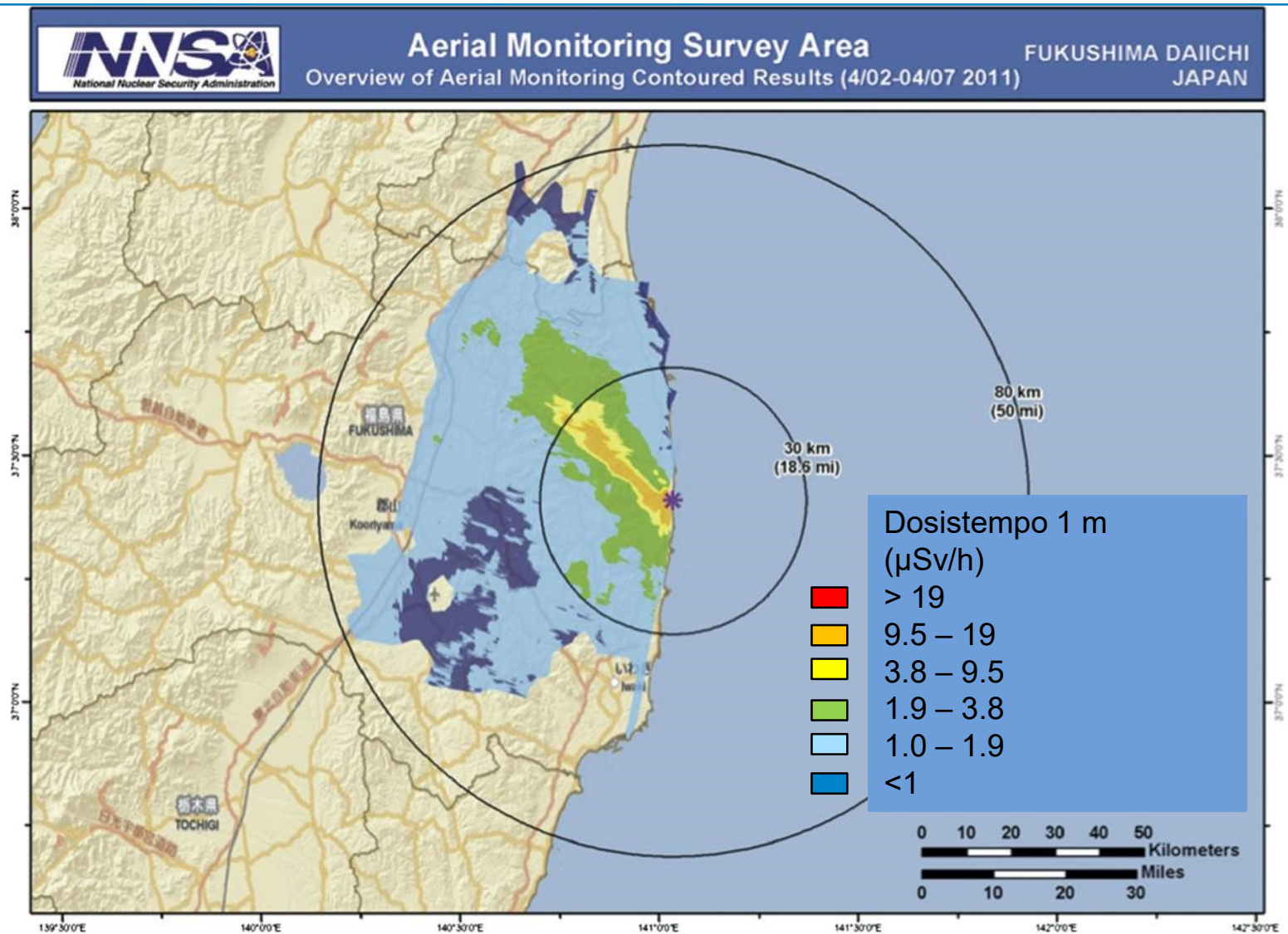
- **March 11** (2011) : Earthquake results in tsunami and subsequent nuclear accident
- **March 14** : American response team leaves for Japan (massive deployment of means, 33 personnel, 8 t. measuring equipment )  
*(it's gonna be huge, really, its enormous, believe me, they're the best)*
- **March 16 & 17** : arrival and first flights
- **March 19** : largest part of *30 km zone* overflown
- **March 22** : First contamination maps produced
- **April 7 th** : all most contaminated areas mapped within *80 km zone*



# March 22nd : no other method is that fast



# Less than one month: rather complete contamination map



# Basically, just put a very large detector in helicopter and fly over the contamination

- Equipment in Belgium : 2 identical **A**erial **G**amma **S**pectrometers (AGS )
  - 2 cases with 2 detectors, NaI, 4 x 4 liter, each case = 50 kg
  - 1 electronics case : 28kg
  - 1 laptop PC + GPS
  - Total weight of 130 kg
- one at SCK (MOL), other one at IRE (Fleurus)
- Setup is very easy, can be done in less than one hour
- Here demonstrated in an A109 Agusta helicopter of Belgian Defense



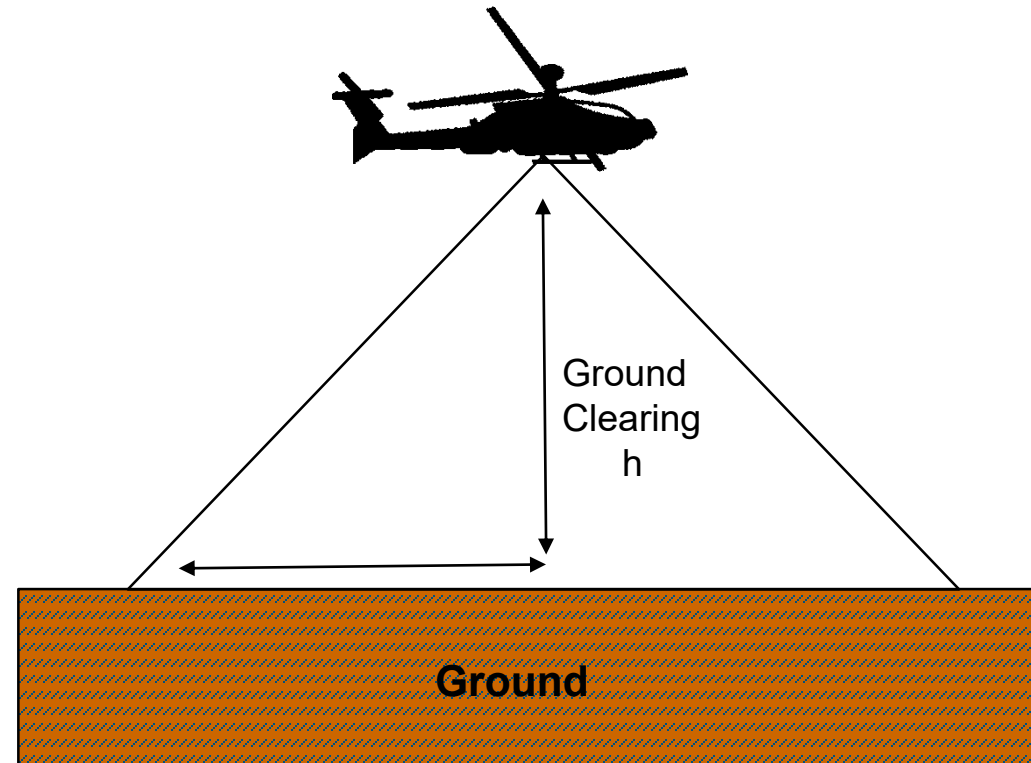
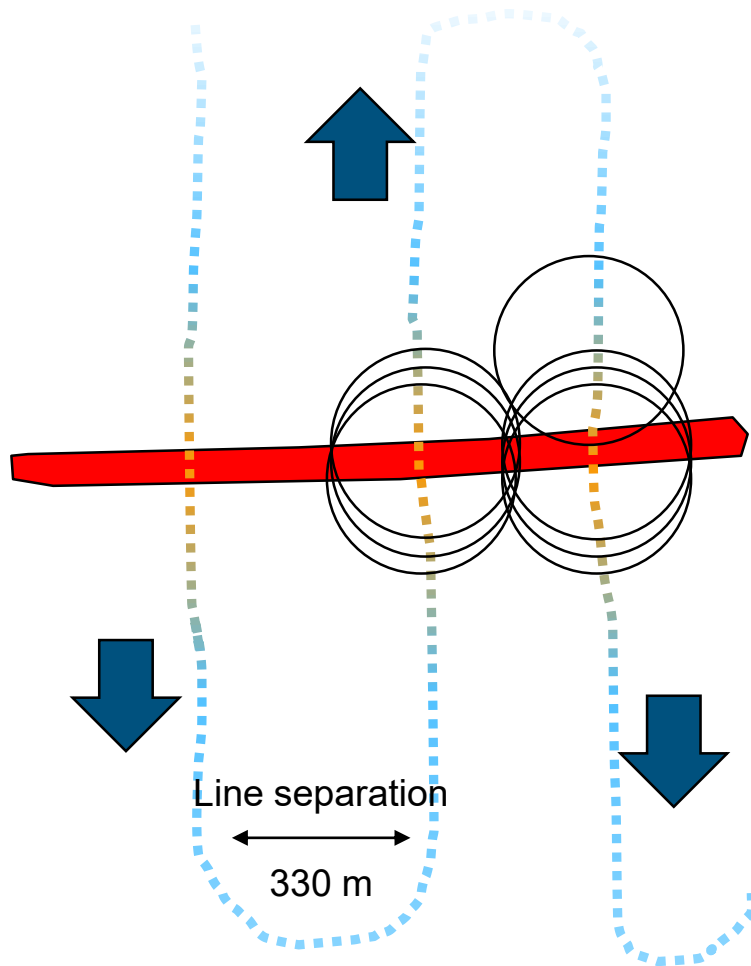
# Typical flight data

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- Flights **only after end** of emissions
  - no inhalation of airborne radioactivity
  - no radioactive contamination of personnel or equipment
  - Flying during accident is pointless : data cannot be interpreted
  - Wait for ground deposition, then measure ground deposition
- Typically:
  - Speed: 100 km/h ( 25 to 30 m/s)
  - Altitude: 150 m
  - Line separation: 500 m
- Fukushima :
  - Over 100 flights, 2 à 3 vectors, 525 flight hours
  - **They started too early !**



# So we produce a "breadcrumb" trail of ground radioactive contamination



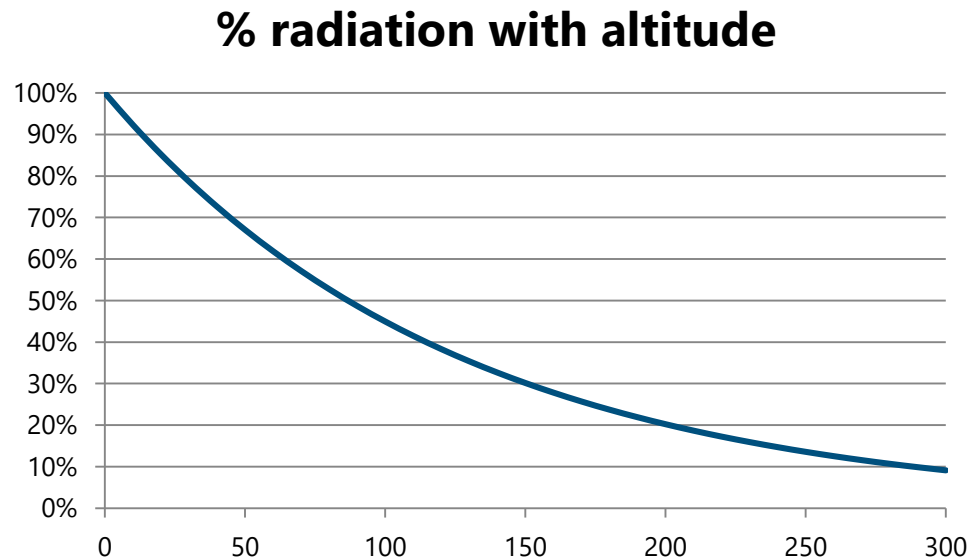
# Various parameters are measured, every second, assuming homogeneous distribution

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- Doserate : on the ground (altitude correction ! )
- NORM : U238 – Th232 - K40 bulk concentrations ( Bq/kg )
- Surface contaminations of Cs137 – I131 – Co60 (Bq/m<sup>2</sup>)
- Presence of other radionuclides ( quite a large library )
- Countrates in windows
  
- Point source strength estimate ( Cs137 – I131- Co60 )
  
- Interpollation of maps during the flight is available on line
- Better maps should be produced off line afterwards

# Altitude correction is very important : automatic now

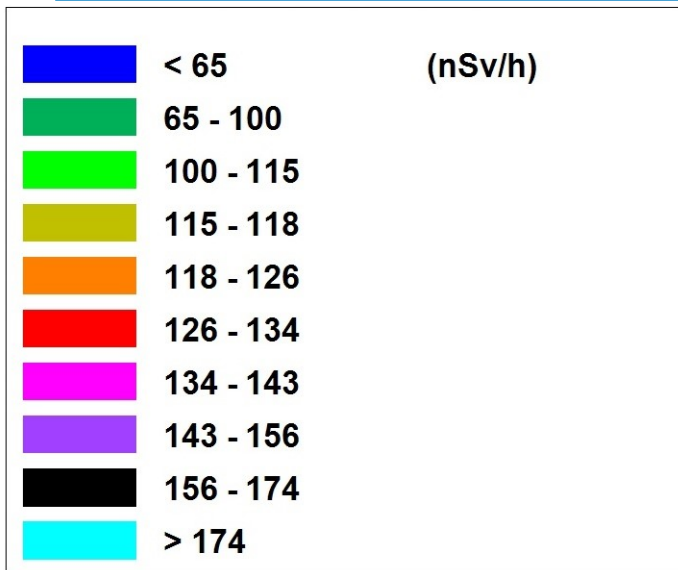
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At 150 m radiation levels drop by 70 %, at 300 m by 90 %

You have to compensate for this ! ! !

# Gypsum and other deposits in Boom – Rupel area

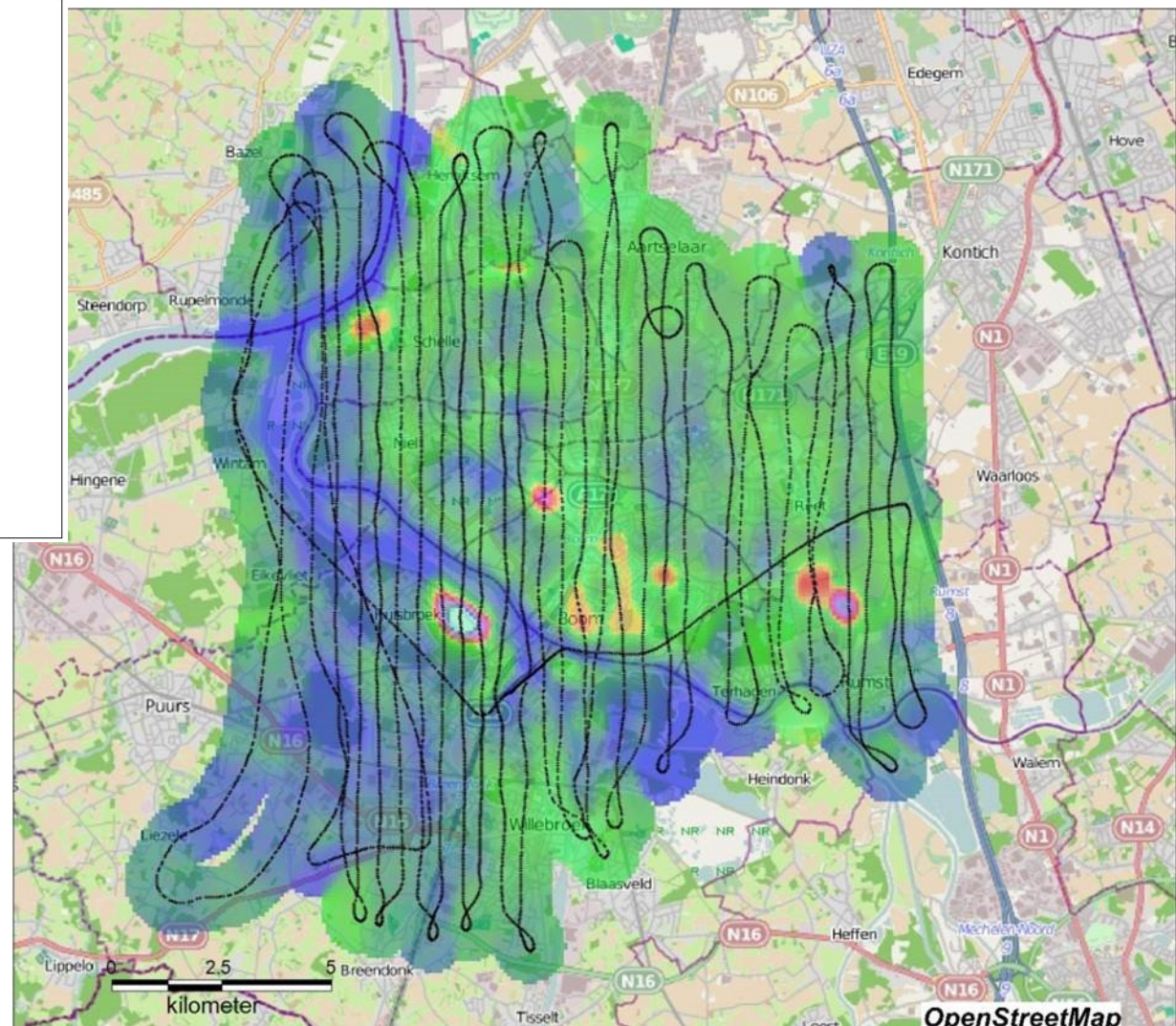


Doserates :

It is better to :

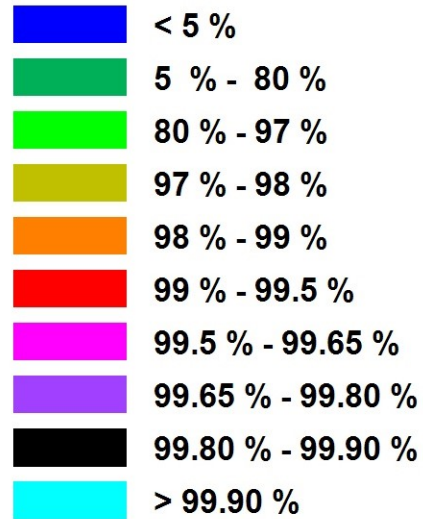
- Look for enhancements
- Look for sudden level changes

Rather than absolute calibrations



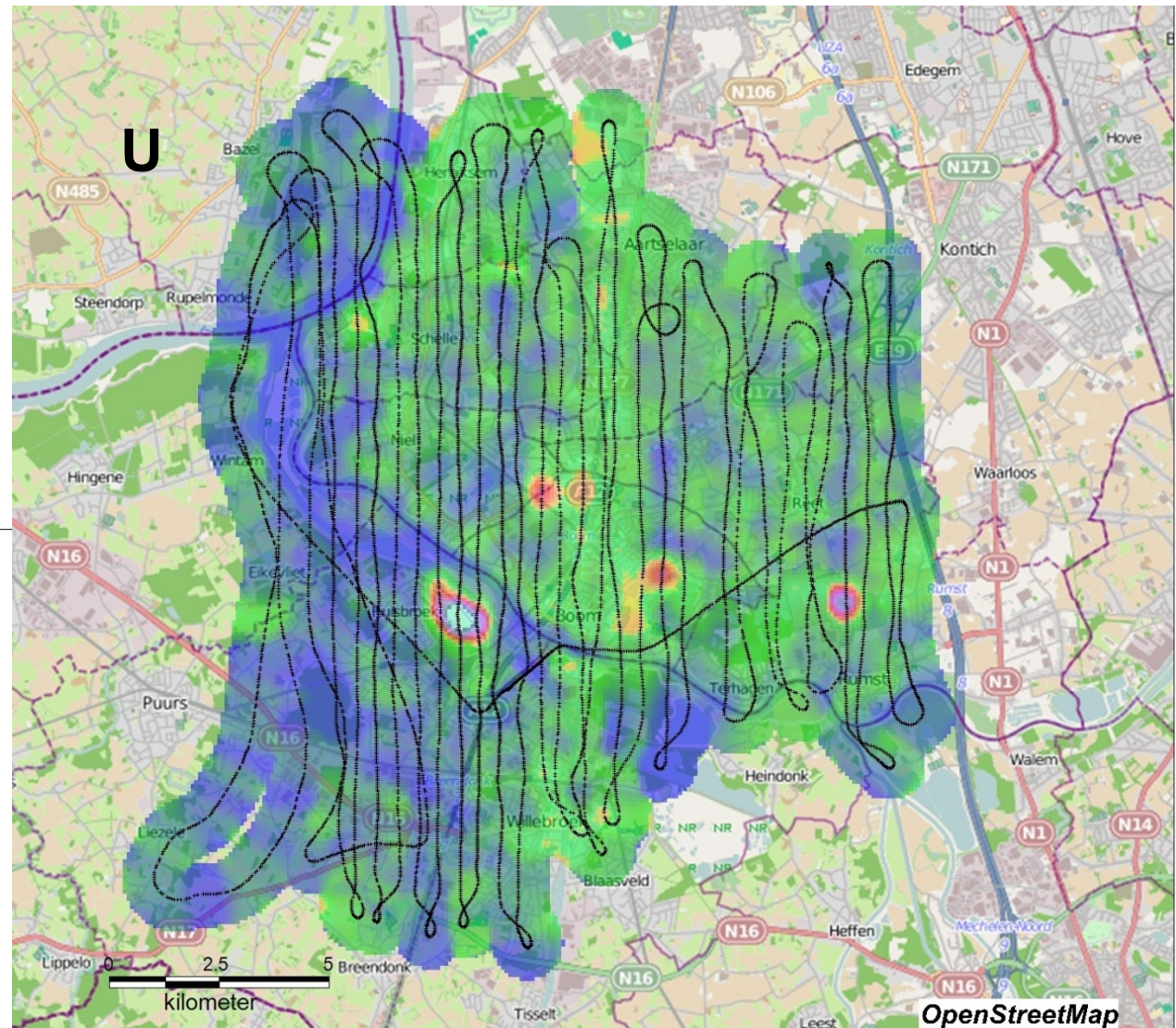


# Compare Th versus U count rate : other contaminants exist



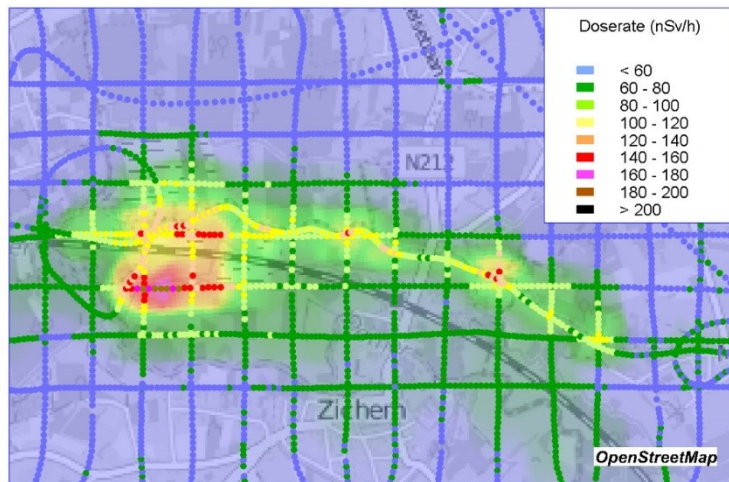
*Area is full of old clay  
pits, filled with all sorts  
of waste*

*Could be fly ash ... or ...*

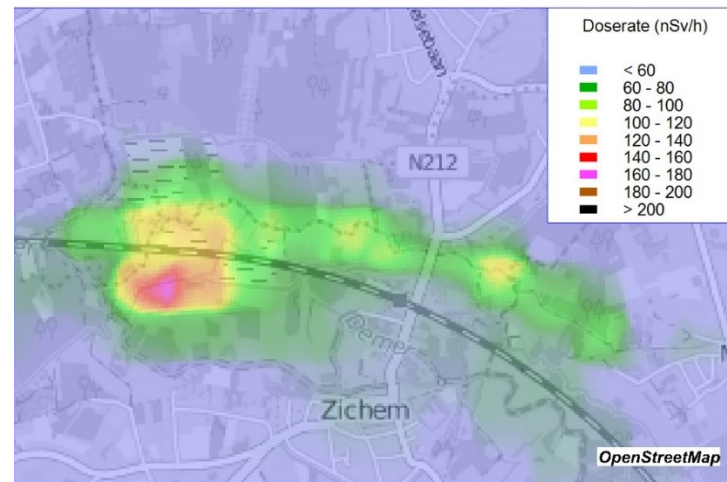




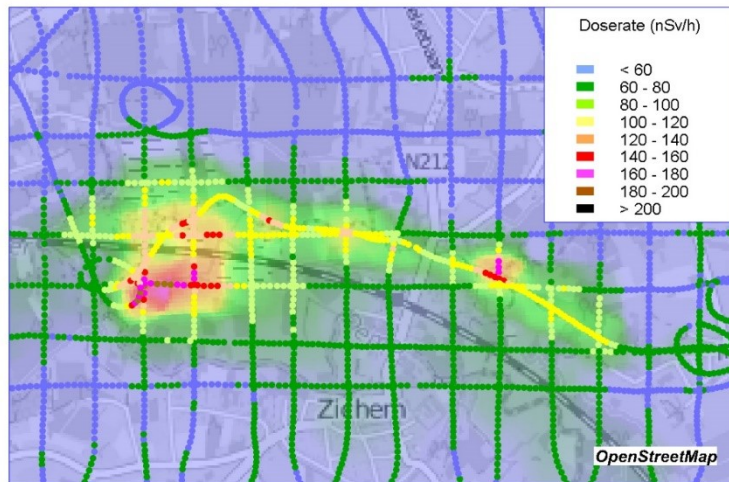
# The two AGS systems yield virtually the exact same results



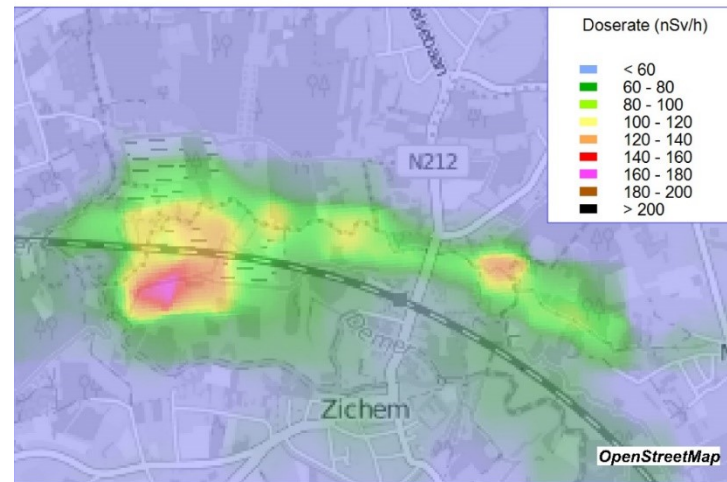
SCK Doserate



SCK Doserate



IRE Doserate



IRE Doserate

Same heli,  
same pilot

Tried to fly  
same flight  
pattern and  
height

250m line  
separation

Two  
directions

70 m ground  
clearing

# Nowadays ... And in the old days



Now we fly helicopters !

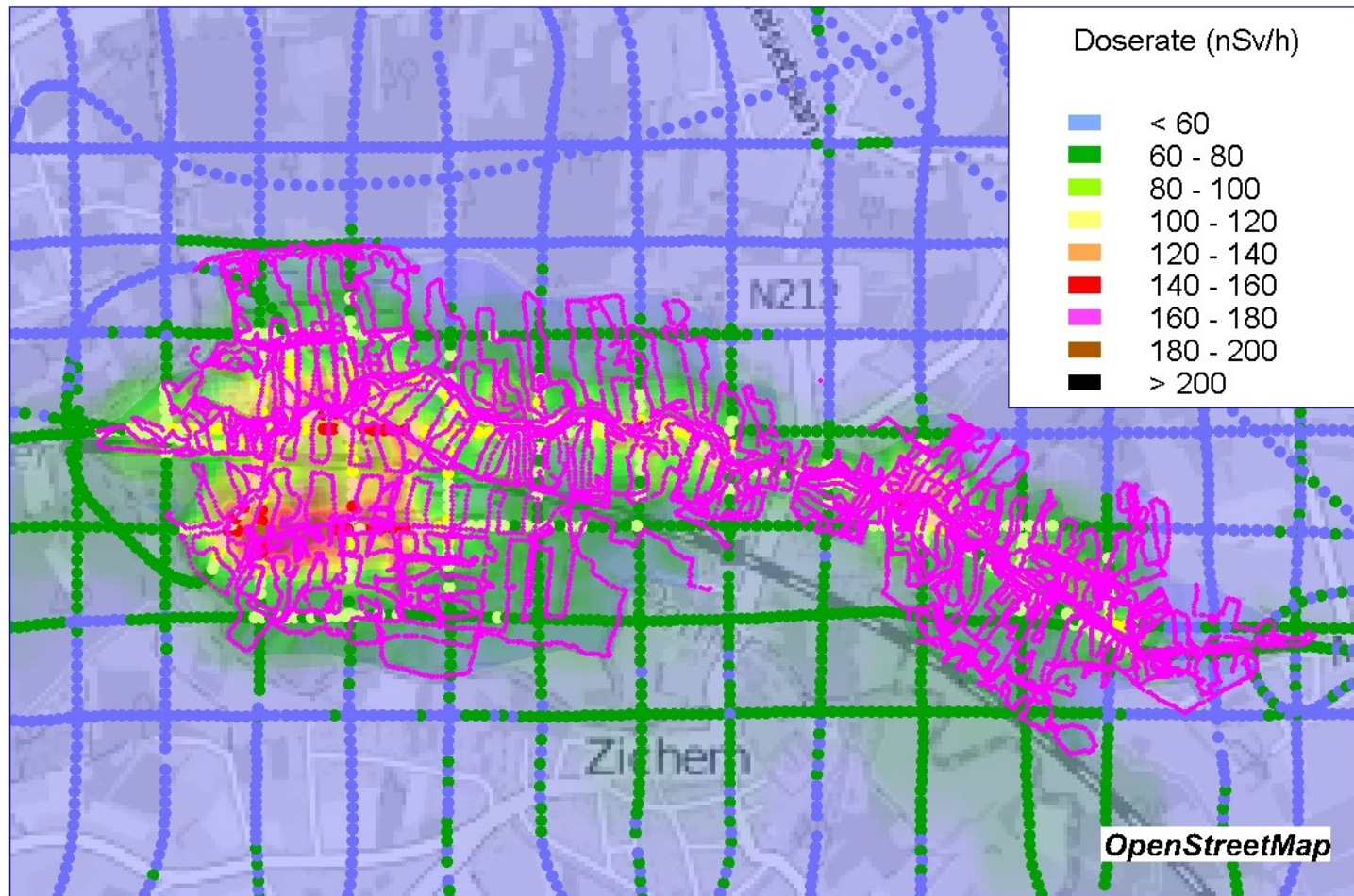
But back then ... We walked !!!



Any Resemblance to Actual Persons, is Purely Coincidental

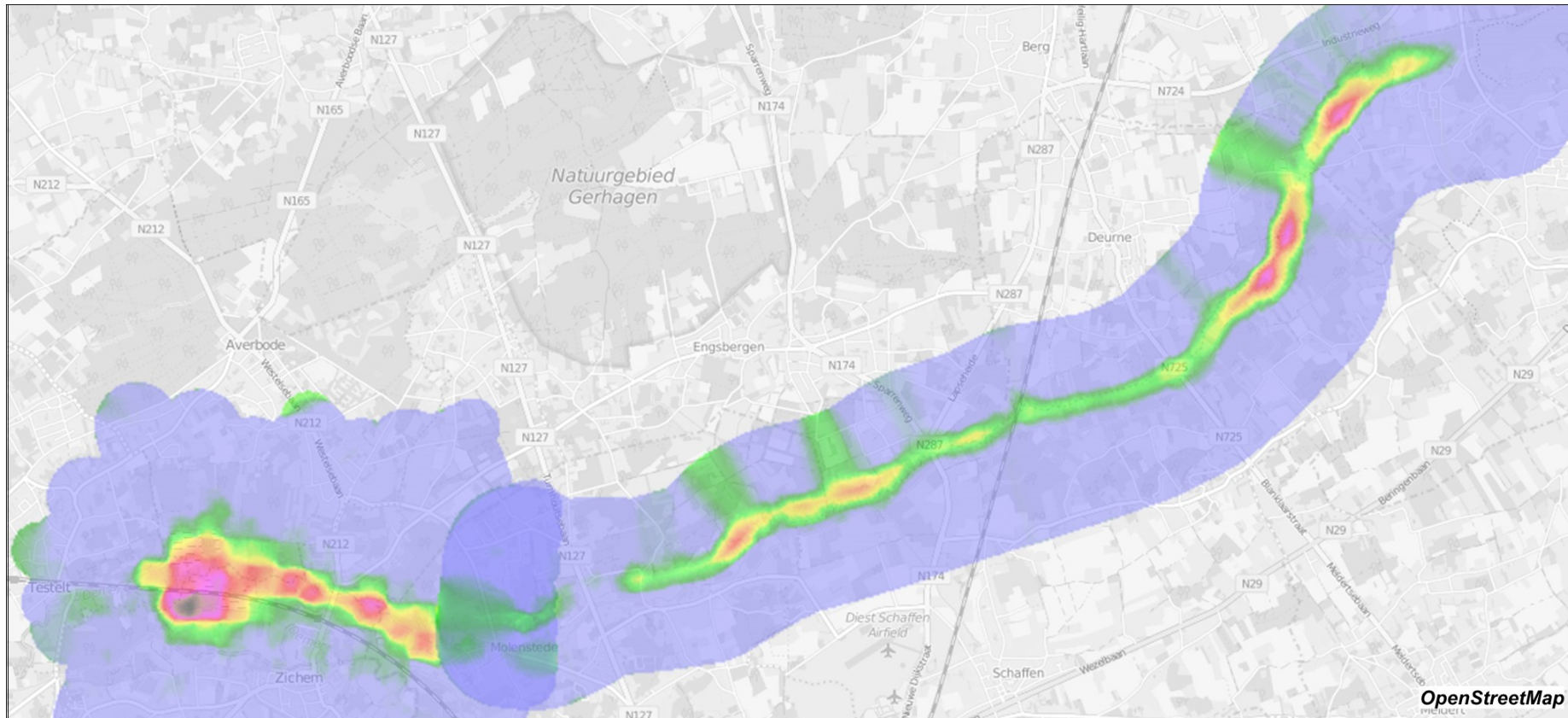


# The helicopter measurements match the foot campaign remarkably well



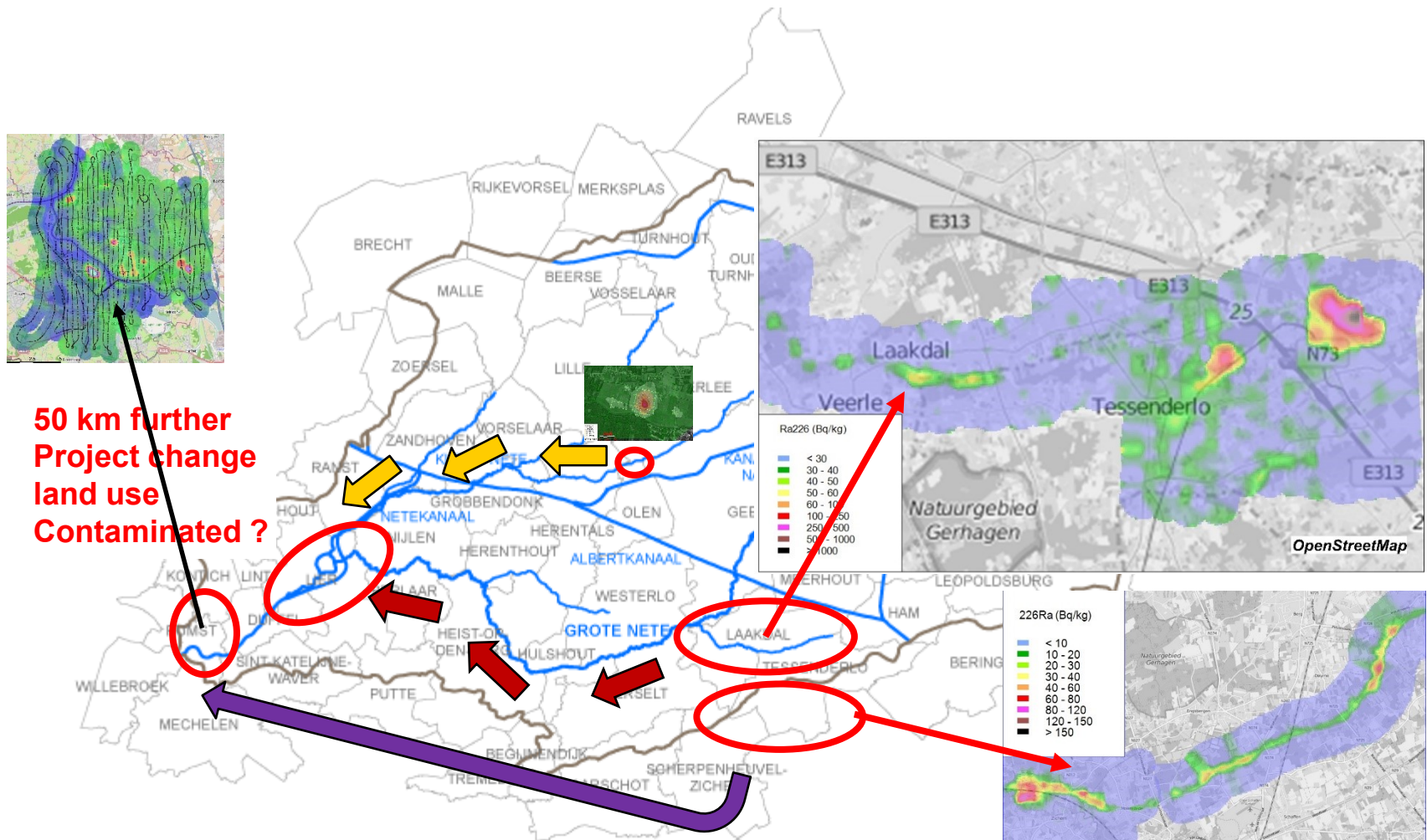
SCK Doserate

# The AGS is very useful for a fast overview of contamination

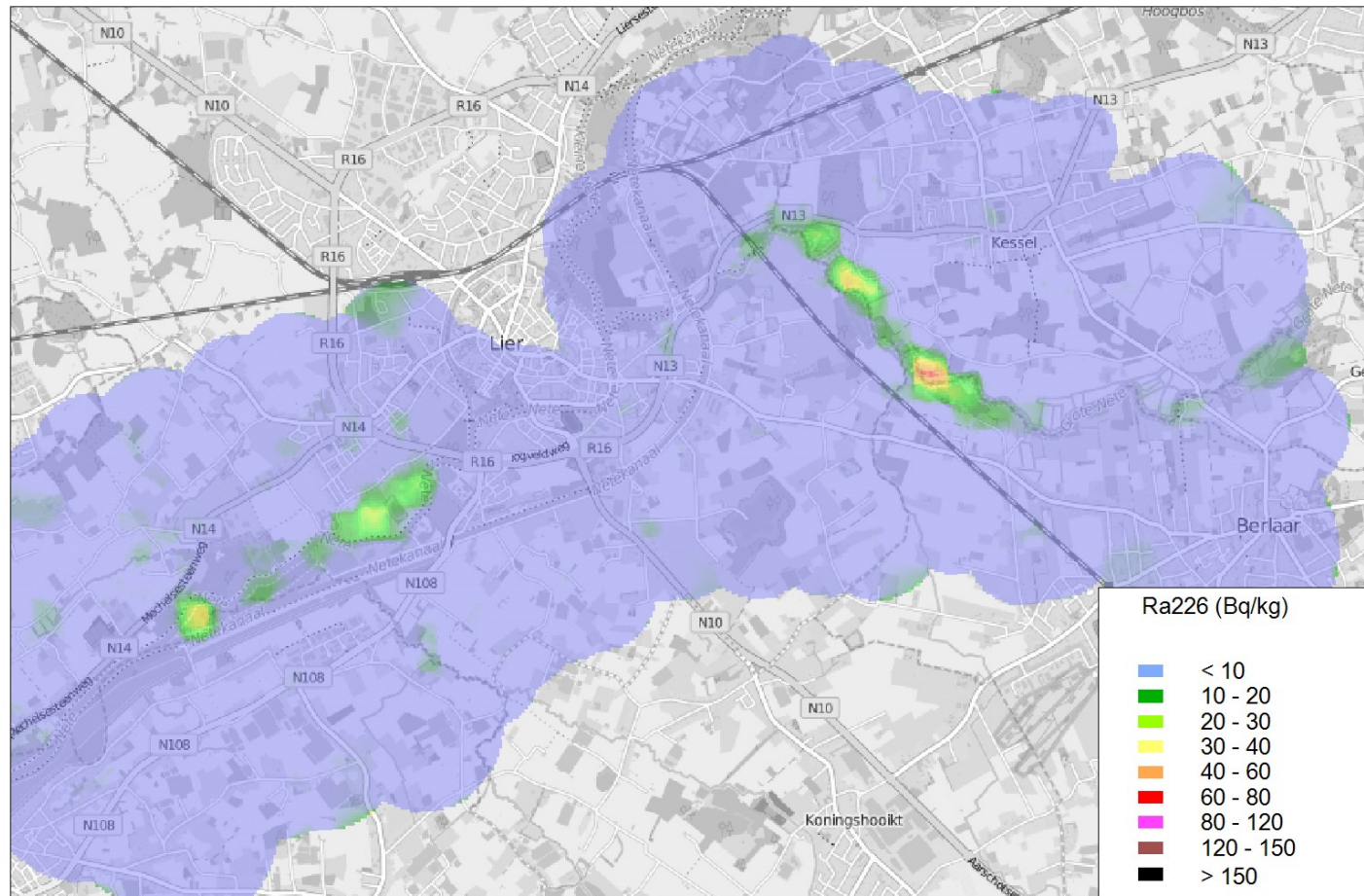




# Helicopter view of complex pattern of radioactive contaminations ...

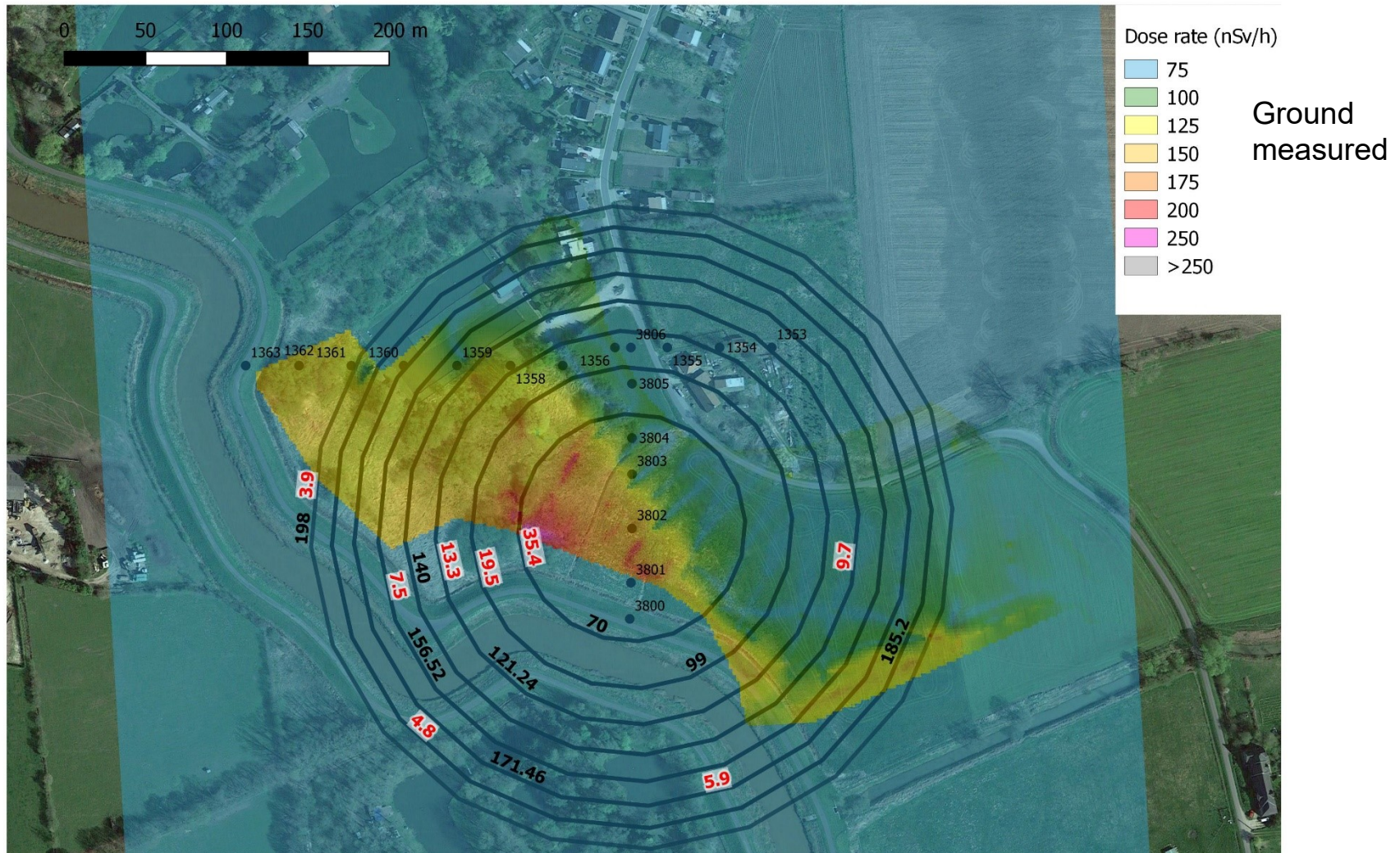


# Guidance to NORM remediation projects : quick scans





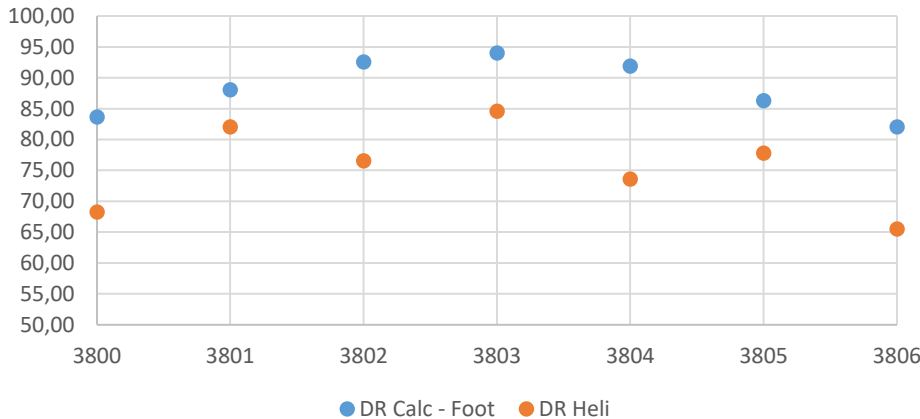
# No large changes in doserate are seen !





# No large changes in doserate are to be expected either !

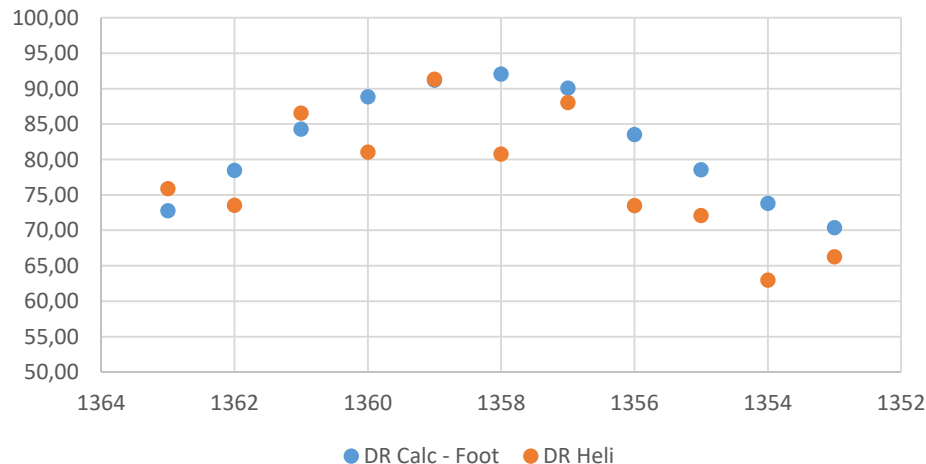
Zuid naar noord



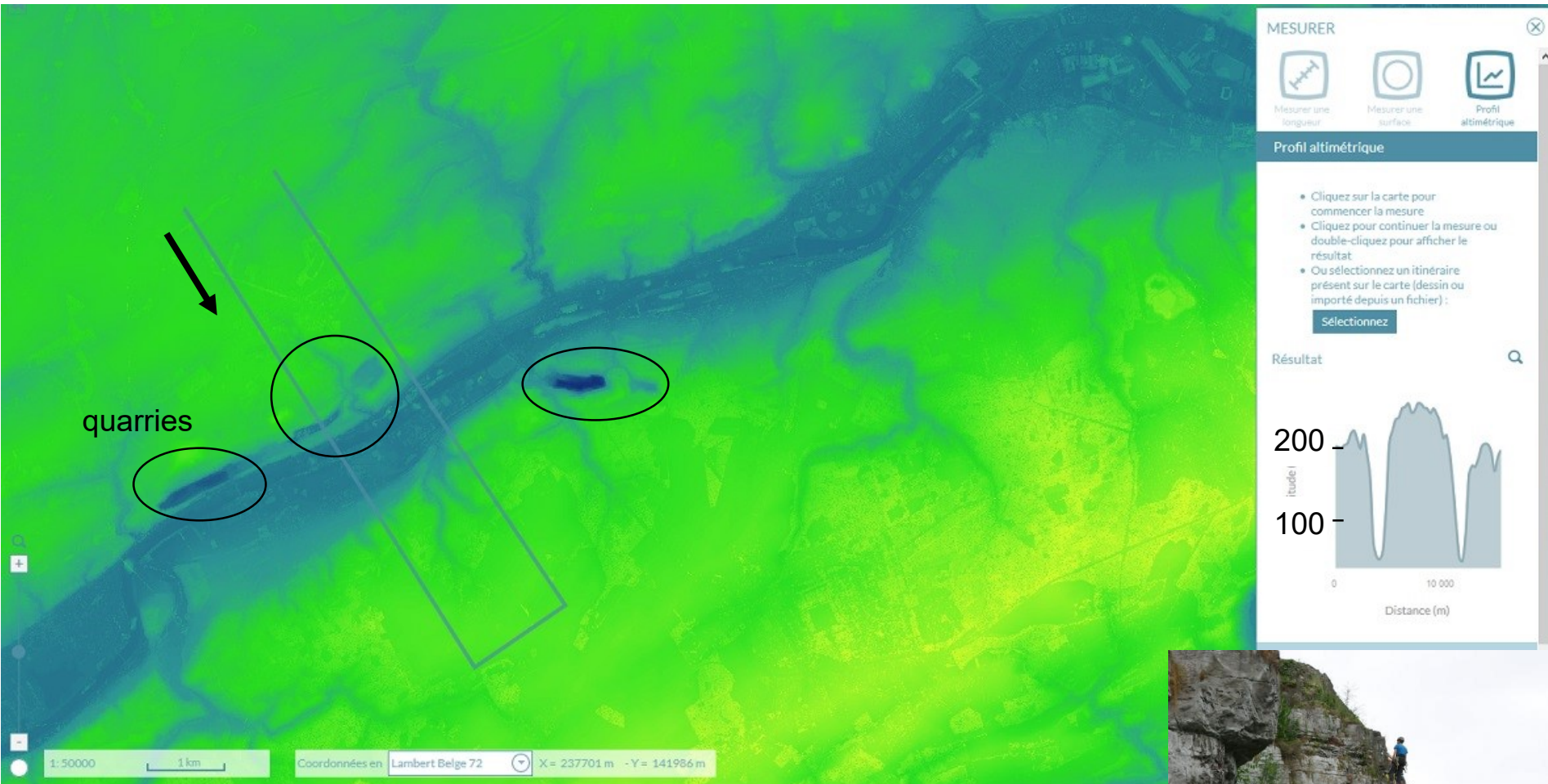
Blue curves :  
calculated change in doserate flying over  
area

Orange curves :  
Observed change in doserate flying over  
area

Oost naar west



# How does the automatic elevation correction perform ?

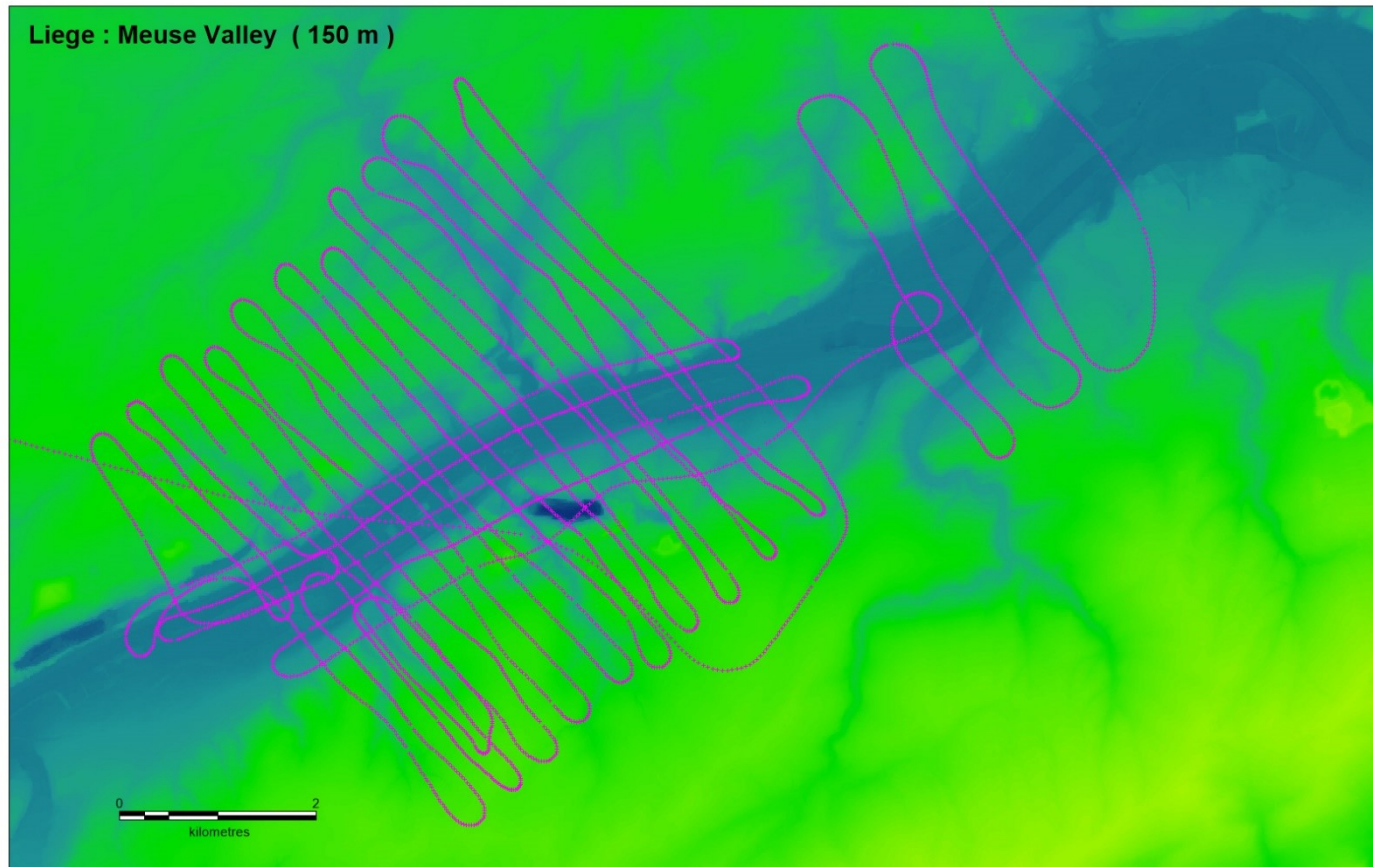


Leaving flat Flanders, flying over Meuse valley (<http://geoportail.wallonie.be>)

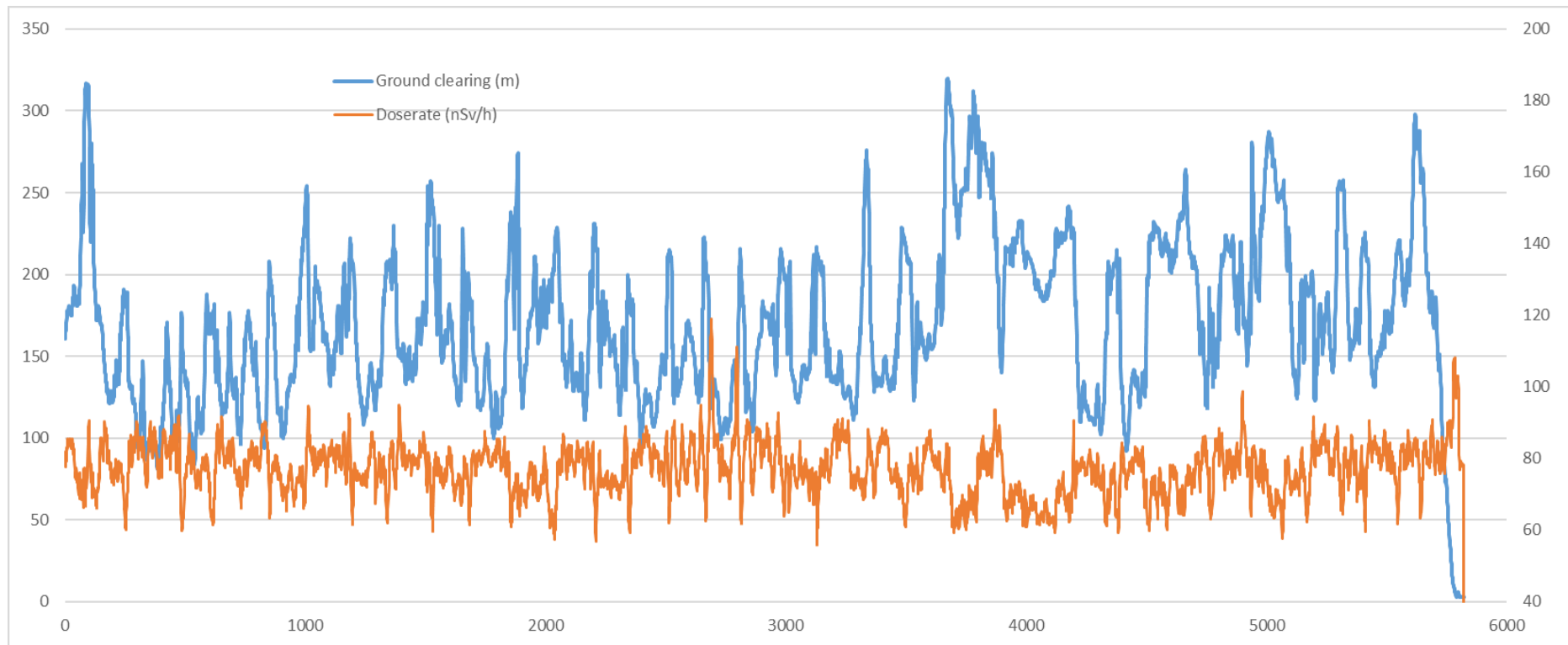


# We flew at constant elevation above the plateau

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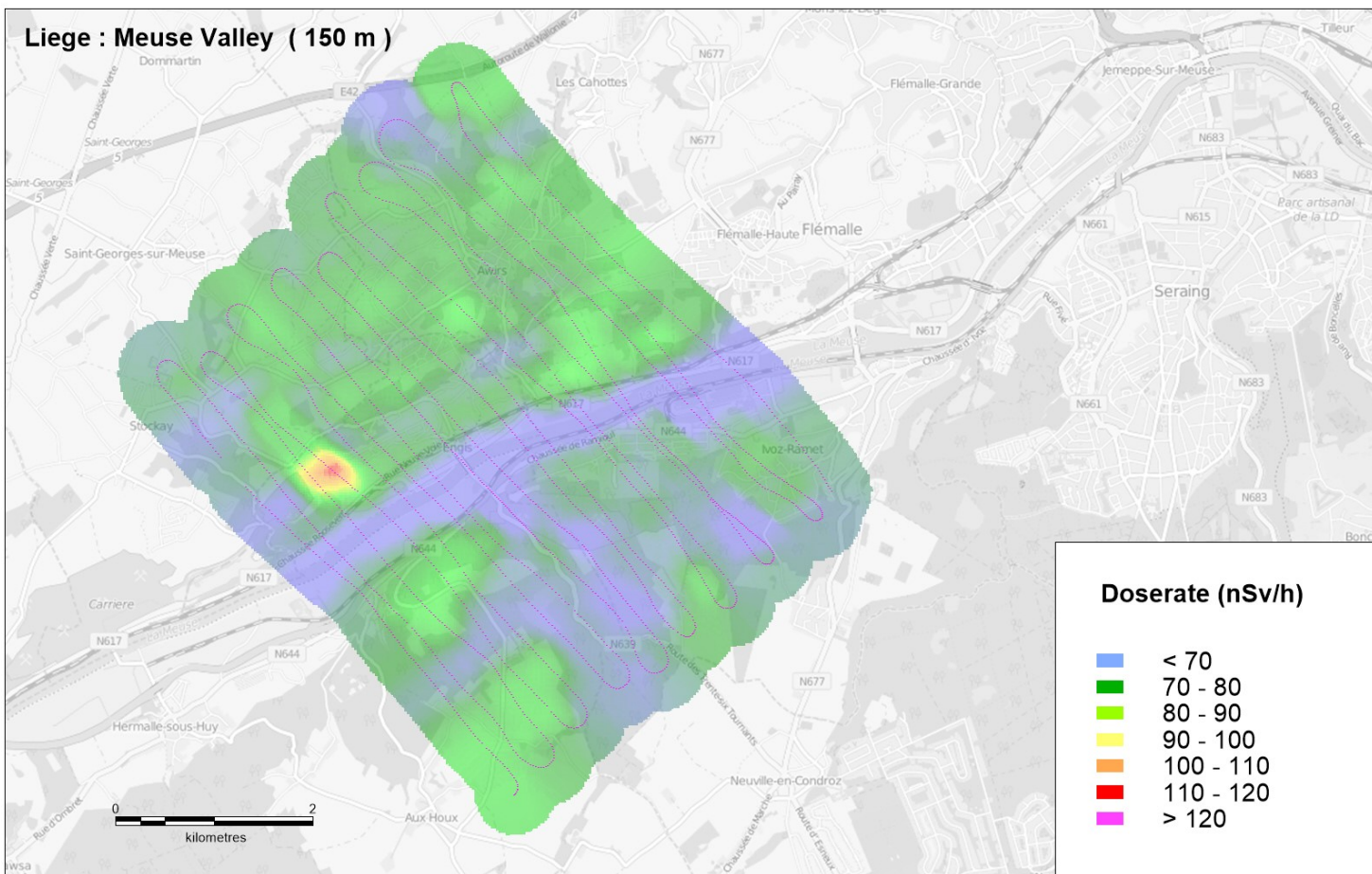
# Which made the ground clearing look like this ...



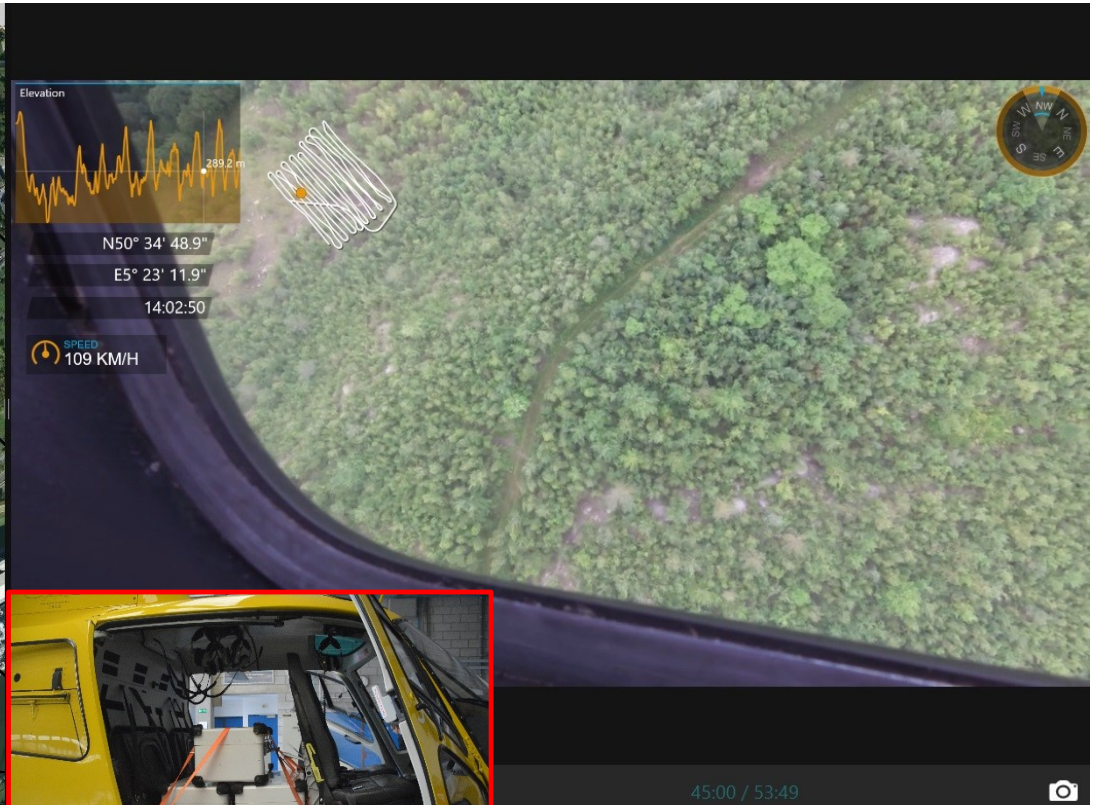
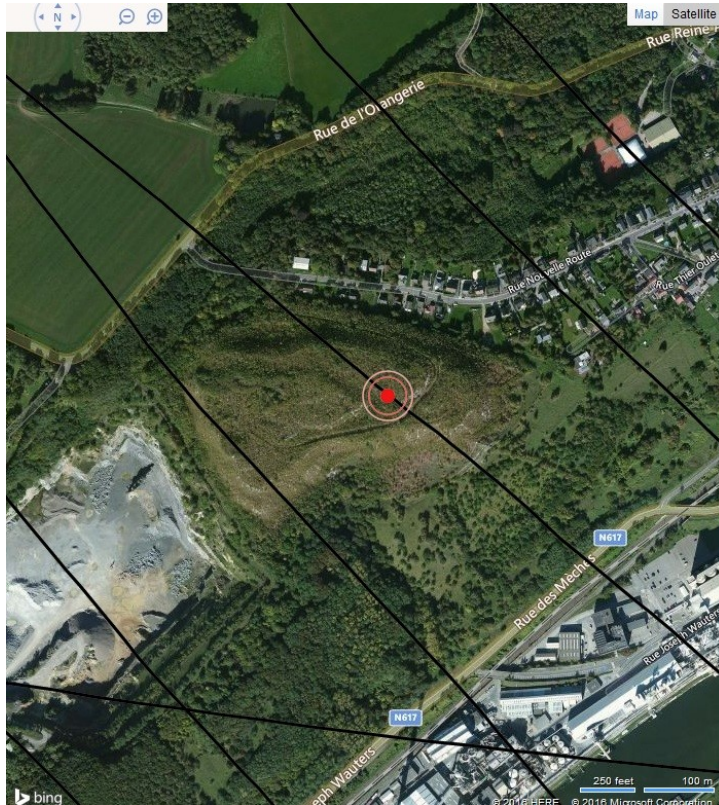
Is there a correlation between measurement values and ground clearing ?



# But the measurements were still very OK

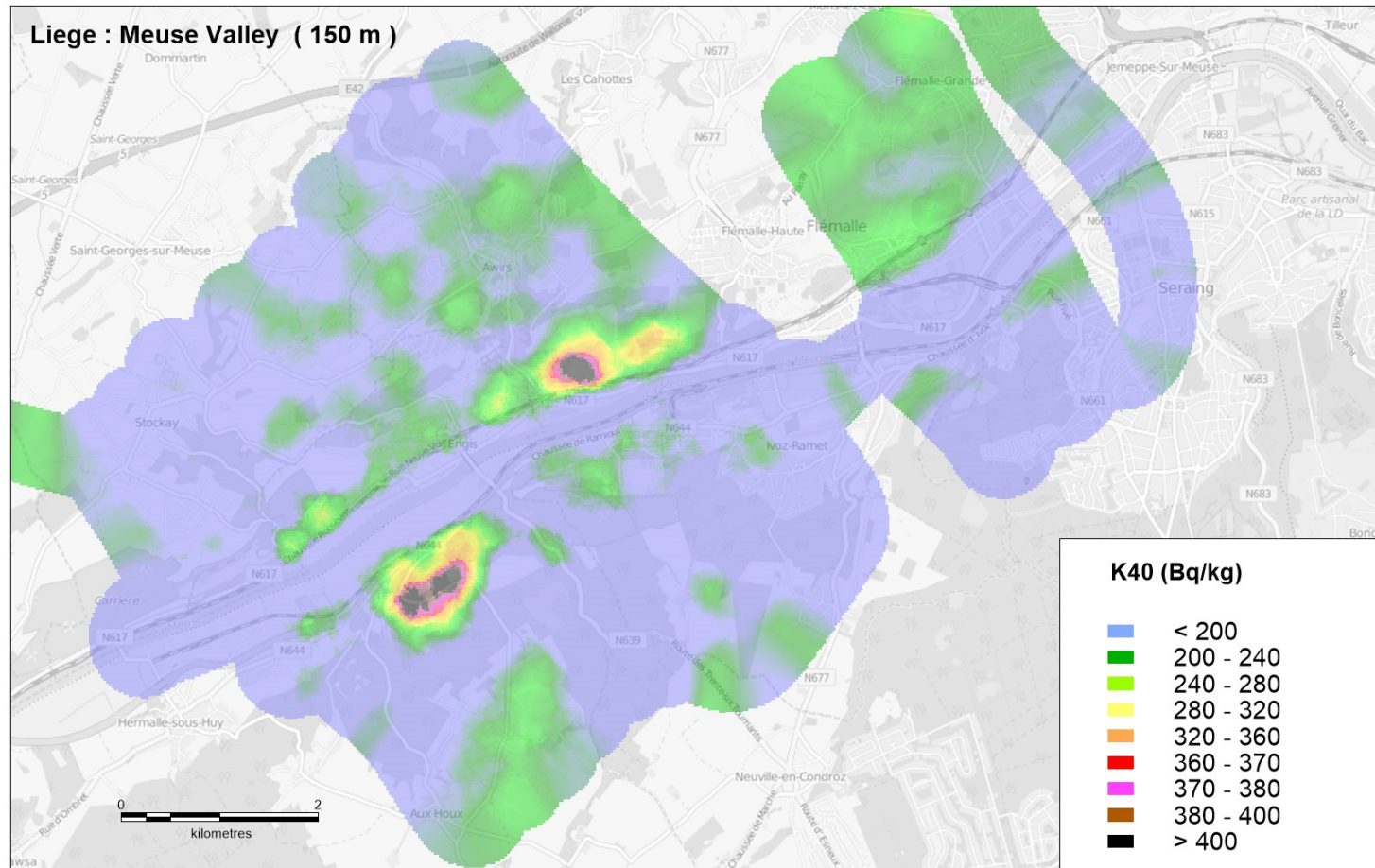


# There is a gypsum deposit, just next to a quarrie





# Also other measurements do not seem affected by tough elevation conditions



# We are ready for quickly mapping ground radioactivity from the air

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- Two equivalent systems, fully interchangeable and ready for use
  - There is automatic ground clearing correction
  - The new interface is user friendly and produces real time satisfying maps ( which one could send to authorities immediately)
- We have an agreement with Belgian defense for use of A109 helicopters in case of emergency and also for practice
- We have contacts with private helicopter firms, for example for specific tasks or contract flights



# Immediately post flight : PDF or KML (G earth )

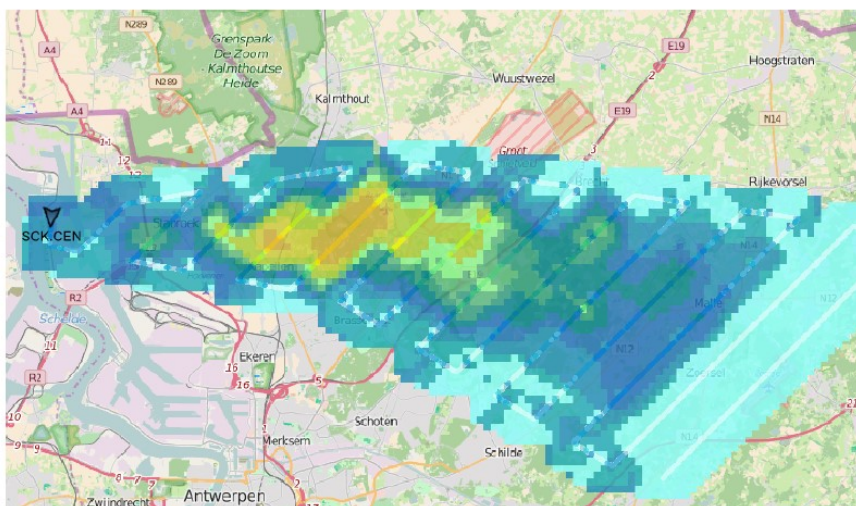


**MIRION**  
TECHNOLOGIES

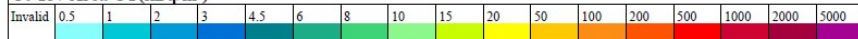
Health Physics  
Division



Unit :	SCK.CEN	Mission :	AGS new soft Doel Sim
Start time :	9/20/2016 2:29:29 PM	End time :	9/20/2016 3:25:33 PM
Mission Dose (G) :	0.02 $\mu$ Sv		
Comments	simulation Doel to Beerse Grobb only Cs137		



Cs-137 Area CT (kBq/m²)



#	Date	Type	Description
1	9/20/2016 2:29:30 PM	Information	Mission started
2	9/20/2016 3:22:02 PM	Information	Mission paused
3	9/20/2016 3:25:33 PM	Information	Mission stopped

Levels can be set almost freely : here  
example :

0.5, 1, 2, 3, 4.5, 6, 8, 10, 15, 20 , 50 , .....

Best before, and save in color file

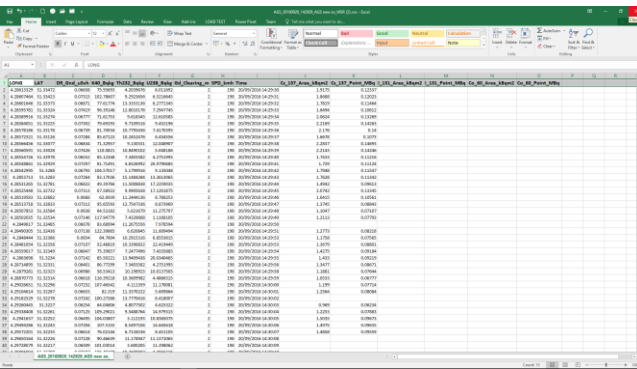
And can be scaled real time : from 0.1 to 10  
Here scale factor 1

Very flexible tool

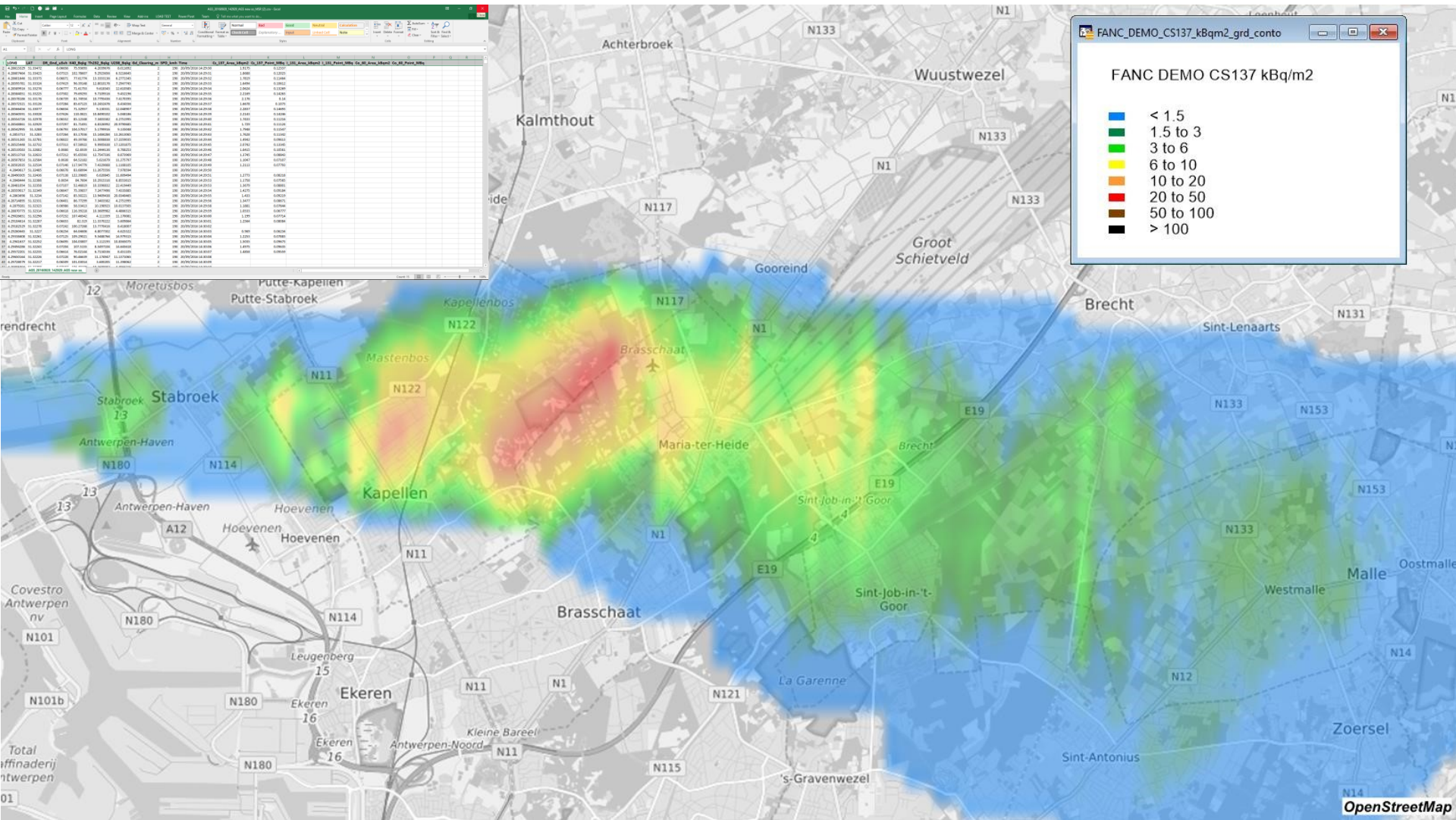




# For producing more elaborated maps : crisis center !



Layer	Lat	Long	Value	Other Attributes
1	50.851111	4.311111	0.0000	...
2	50.851111	4.311111	0.0000	...
3	50.851111	4.311111	0.0000	...
4	50.851111	4.311111	0.0000	...
5	50.851111	4.311111	0.0000	...
6	50.851111	4.311111	0.0000	...
7	50.851111	4.311111	0.0000	...
8	50.851111	4.311111	0.0000	...
9	50.851111	4.311111	0.0000	...
10	50.851111	4.311111	0.0000	...
11	50.851111	4.311111	0.0000	...
12	50.851111	4.311111	0.0000	...
13	50.851111	4.311111	0.0000	...
14	50.851111	4.311111	0.0000	...
15	50.851111	4.311111	0.0000	...
16	50.851111	4.311111	0.0000	...
17	50.851111	4.311111	0.0000	...
18	50.851111	4.311111	0.0000	...
19	50.851111	4.311111	0.0000	...
20	50.851111	4.311111	0.0000	...
21	50.851111	4.311111	0.0000	...
22	50.851111	4.311111	0.0000	...
23	50.851111	4.311111	0.0000	...
24	50.851111	4.311111	0.0000	...
25	50.851111	4.311111	0.0000	...
26	50.851111	4.311111	0.0000	...
27	50.851111	4.311111	0.0000	...
28	50.851111	4.311111	0.0000	...
29	50.851111	4.311111	0.0000	...
30	50.851111	4.311111	0.0000	...
31	50.851111	4.311111	0.0000	...
32	50.851111	4.311111	0.0000	...
33	50.851111	4.311111	0.0000	...
34	50.851111	4.311111	0.0000	...
35	50.851111	4.311111	0.0000	...
36	50.851111	4.311111	0.0000	...
37	50.851111	4.311111	0.0000	...
38	50.851111	4.311111	0.0000	...
39	50.851111	4.311111	0.0000	...
40	50.851111	4.311111	0.0000	...
41	50.851111	4.311111	0.0000	...
42	50.851111	4.311111	0.0000	...
43	50.851111	4.311111	0.0000	...
44	50.851111	4.311111	0.0000	...
45	50.851111	4.311111	0.0000	...
46	50.851111	4.311111	0.0000	...
47	50.851111	4.311111	0.0000	...
48	50.851111	4.311111	0.0000	...
49	50.851111	4.311111	0.0000	...
50	50.851111	4.311111	0.0000	...



## Some thoughts ...

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- Elaboration of the produced data is very important :
  - Maps are produced by the system itself but ...
  - Mapping is an "art" : ***There needs to be capability for producing maps in a flexible way at the crisis centre ... To do list !***
- Perhaps we should think about "universal automatic mapping" system, based on open source ( GIS ? ) software
- Lots of experience by now, but only NORM ( phosphate industry)
- Could we ever try this system on artificial contamination : would be interesting

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Thanks for your kind attention

