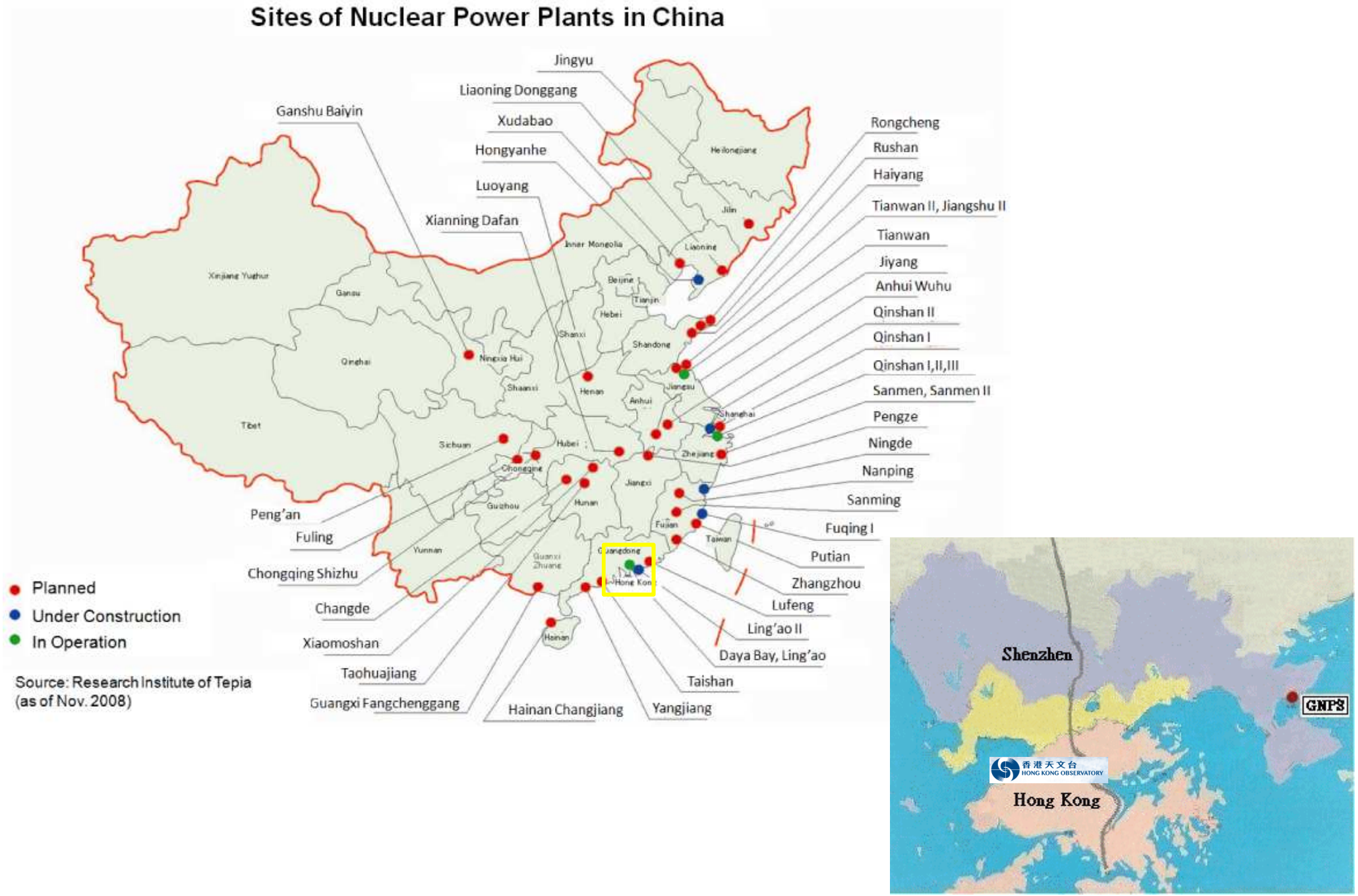
EXERCISE 2
Backward “Hello World” NPP example, Forward NPP example

Aims:

1. Backward:
    1. Familiarise with FLEXPART run in backward mode
    2. Understand the strengths and limits of backtracking a single measurement – poor man’s inversion
2. Forward:
    1. How to set a realistic multi-species scenario
    2. Influence of grid, depositing characteristics
    3. Thinking towards emergency response

Questions? Write delia.arnold-arias@zamg.ac.at

Bwd run from HKO



Bwd run from HKO

- 1 day integration measurement of Xe-133 (can be treated as a tracer) at the HKO 22.3025° N, 114.1742° E
- Measurement integration period 2014.10.12 00:00 - 2014.10.13 00:00
- Measurement inlet at 60 m a.g.l.
- Backtracking for 3 days
- Interested in potential emissions at ground level, therefore OUTGRID will only need one level, relatively shallow, 150 m a.g.l.
- Remember to carefully check the COMMAND
- Output every three hours

2014.10.12 00:00 - 2014.10.13 00:00 – Measurement at HKO! 4x10**4 Bq/m3 Xe-133

Bwd run from HKO

This test case aims at making you run FLEXPART with a simple bwd case and understand the results and what information can be extracted from them.

- Specifications:
  - COMMAND FILE:
    - Backward run: 9 October 2014 00 UTC to 13 October 2014 00 UTC
    - Output every 3 hours
    - Convection
    - Residence times output
    - No nested output
    - No adaptation to TL
  - OUTGRID FILE:
    - Resolution 0.2 degree
    - LLC: 20.0° N, 100.0° E
    - 100x150 grid cells
    - 1 output layer, 150 m agl
  - RELEASES FILE:
    - Point source at the top of the HKO building: 22.3025° N, 114.1742° E, 60 m agl
    - Release start: 12 October 2014 00 UTC
    - Release end: 13 October 2014 00 UTC
    - Total mass: 1 kg of Xe-133
    - Particles released: 10000

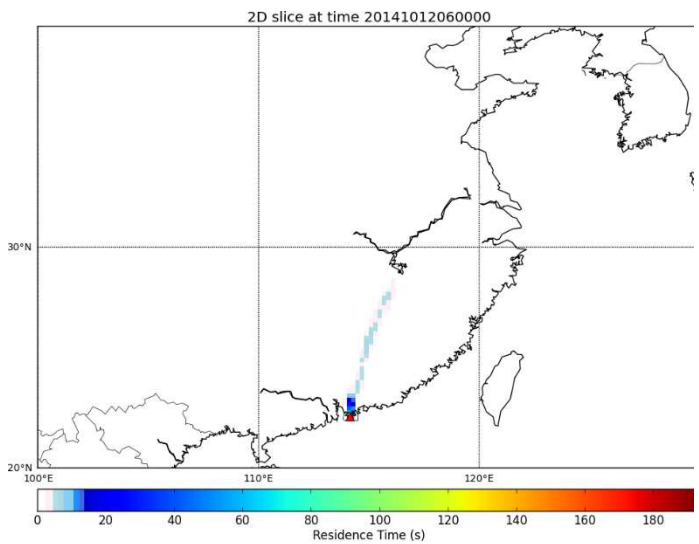
Bwd run from HKO

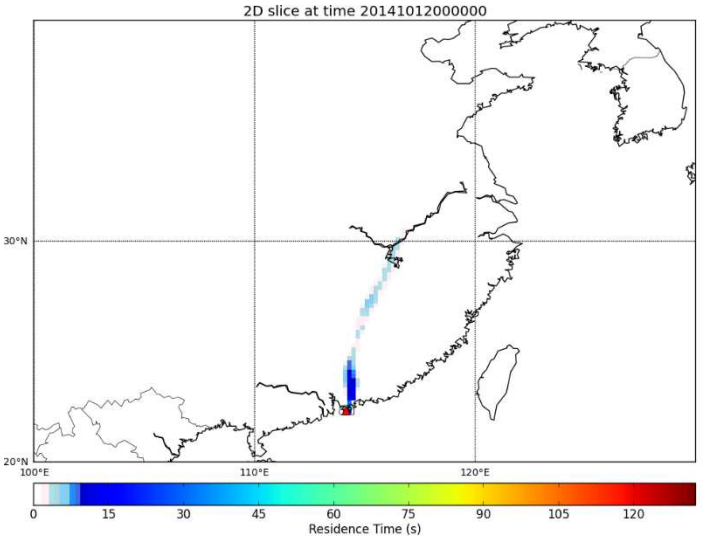
- 1 day integration measurement of Xe-133 (can be treated as a tracer) at the HKO 22.3025° N, 114.1742° E
- Measurement integration period 2014.10.12 00:00 - 2014.10.13 00:00
- Measurement inlet at 60 m a.g.l.
- Backtracking for 3 days before measurement start
- Interested in potential emissions at ground level, therefore OUTGRID will only need one level, relatively shallow, 150 m a.g.l.
- Remember to carefully check the COMMAND
- Output every three hours

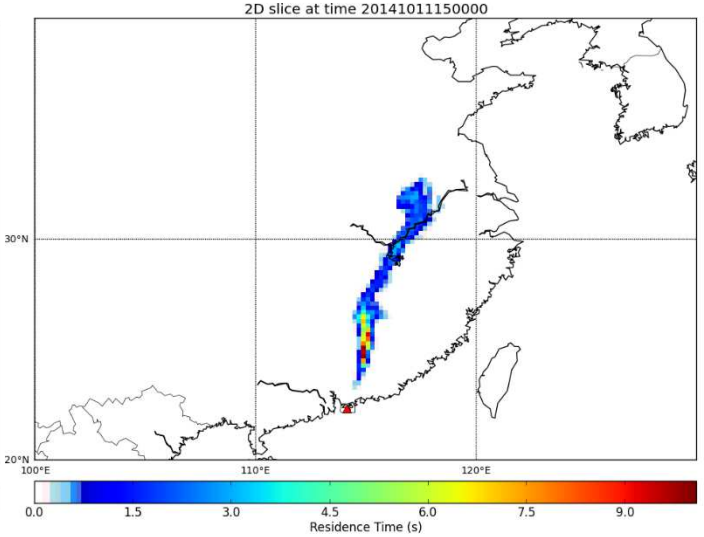
```
 Welcome to FLEXPART Version 10.3beta (2019-04-05)
FLEXPART is free software released under the GNU General Public License.
          ----------
 INFORMATION: SUBGRIDSCALE TERRAIN EFFECT IS
 NOT PARAMETERIZED DURING THIS SIMULATION.
          ----------
ECMWF metdata detected
Vertical levels in ECMWF data:     138    138

Mother domain:
 Longitude range:  100.00000 to  130.00000   Grid distance:    0.20000
 Latitude range :   20.00000 to   40.00000   Grid distance:    0.20000

Releasepoints :           1

SPECIES:  21  Xe-133      (GAS)
  Wet removal for gases      is turned: OFF
  Dry deposition for gases   is turned: OFF
  Below-cloud scavenging: OFF
  In-cloud scavenging: OFF
Particles allocated (maxpart)  :      5000000
Particles released (numpartmax):        10000
Total mass released: 1.0000000E+00
Allocating fields for global output (x,y):         150         100
Allocating fields for nested output (x,y):           0           0
Concentrations are calculated using kernel
Simulated     0.0 hours (           0 s),           0 particles
Global ECMWF fields: using cloud water
Global ECMWF fields: using cloud water
Global ECMWF fields: using cloud water
-10800 Seconds simulated:         1302 Particles:    Uncertainty:   0.000  0.000  0.000
Global ECMWF fields: using cloud water
-21600 Seconds simulated:         2552 Particles:    Uncertainty:   0.000  0.000  0.000
```

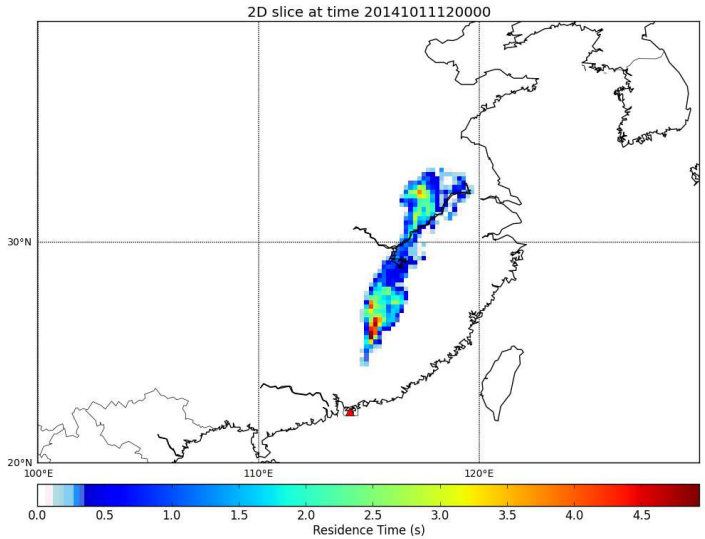
ECMWF (0.2 degr.) : Bwd run from HKO

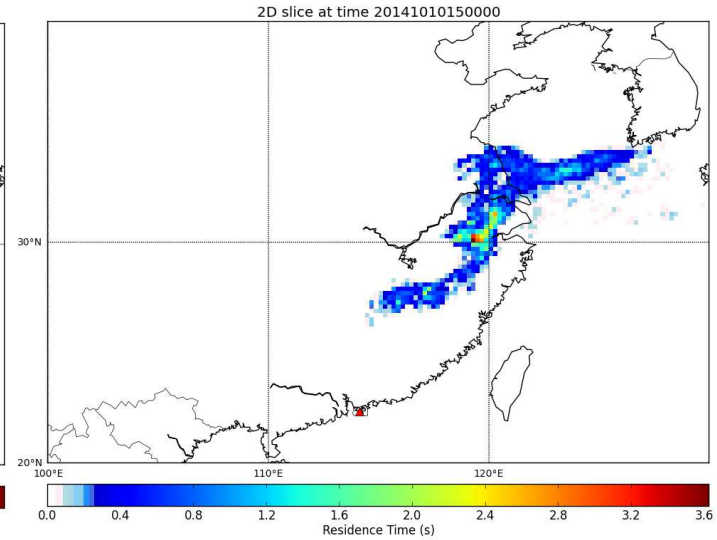
```
./plot_FLEX_binary.py ./output/ False nuc1 0 0 alldates cyl False
100.0,130.0,20.0,40.0 mesh False
[In backward mode all species are treated the same: write nuc1 or tracer1.]
```

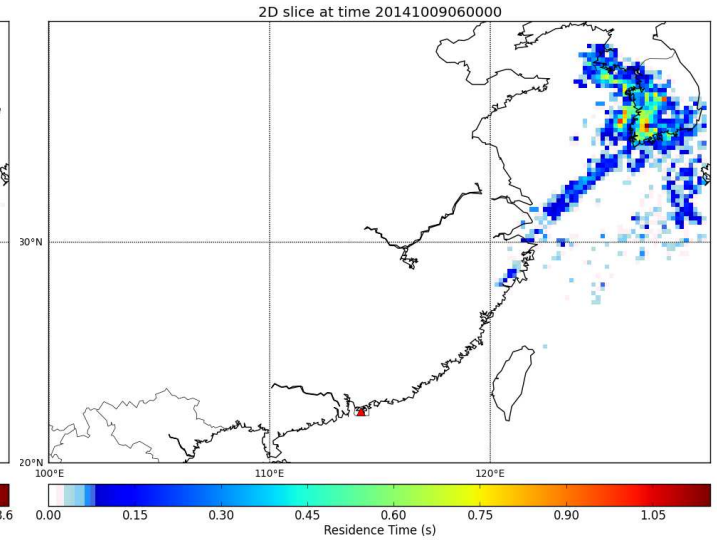






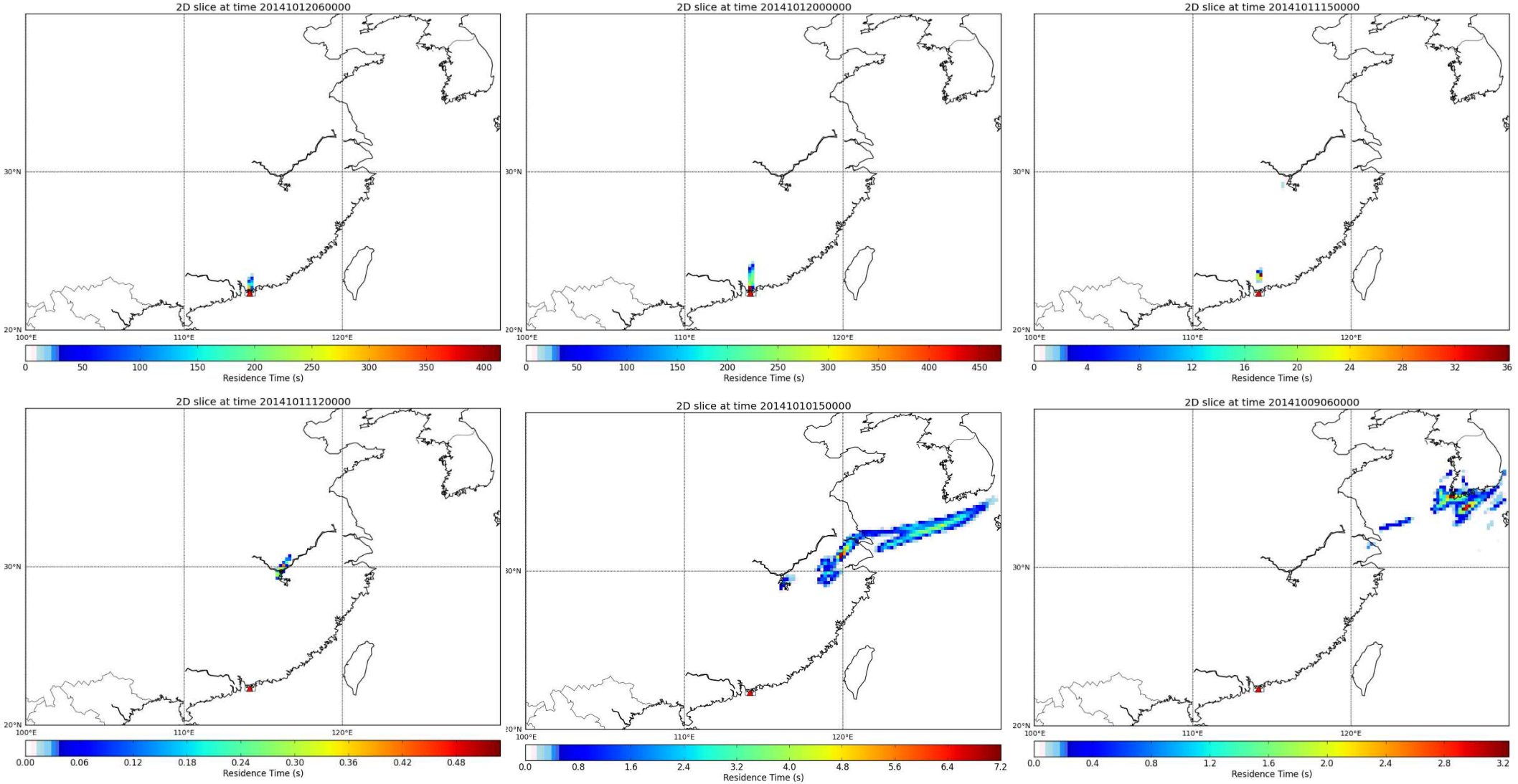






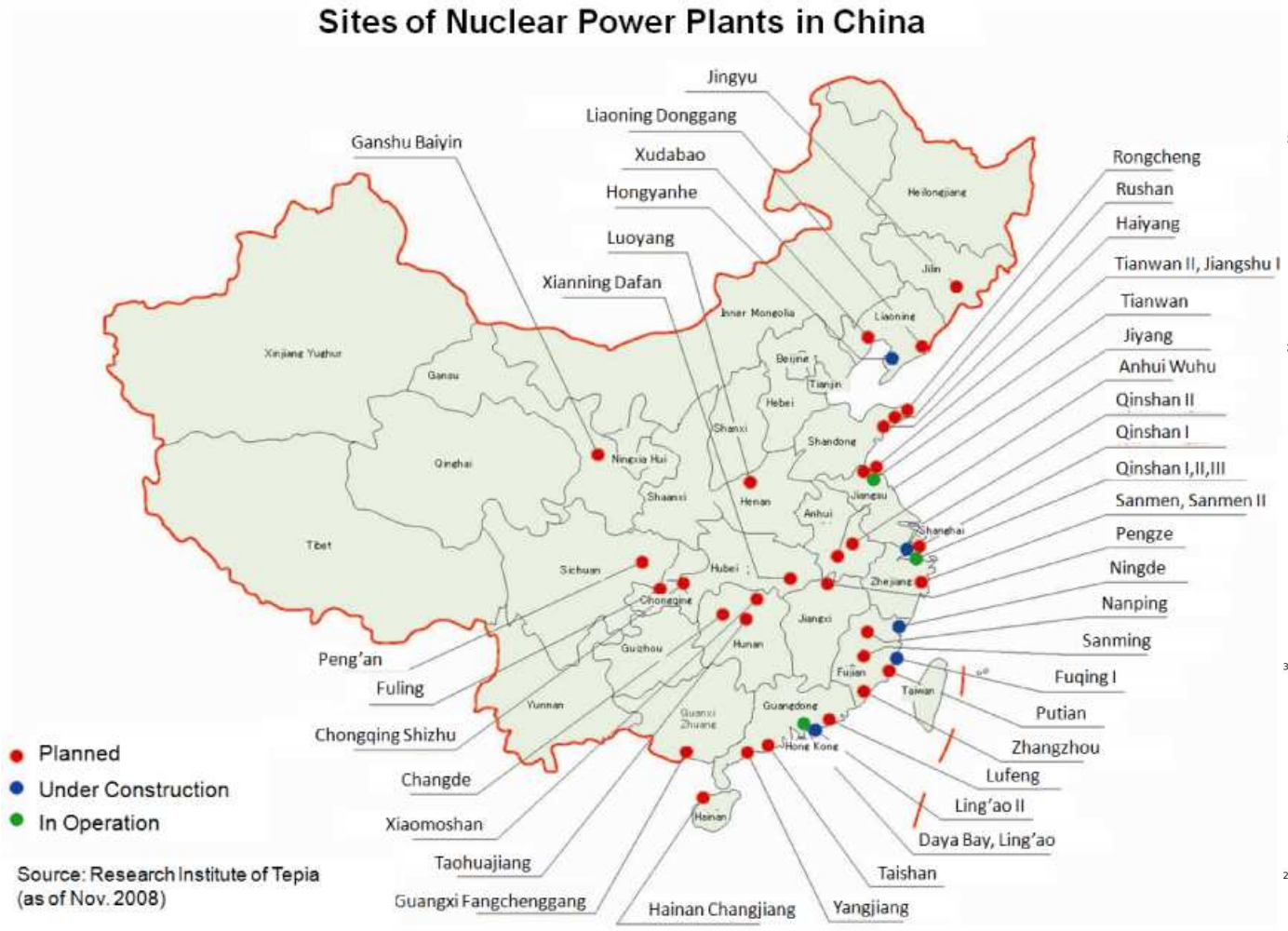
NCEP (0.5 degr.): Bwd run from HKO

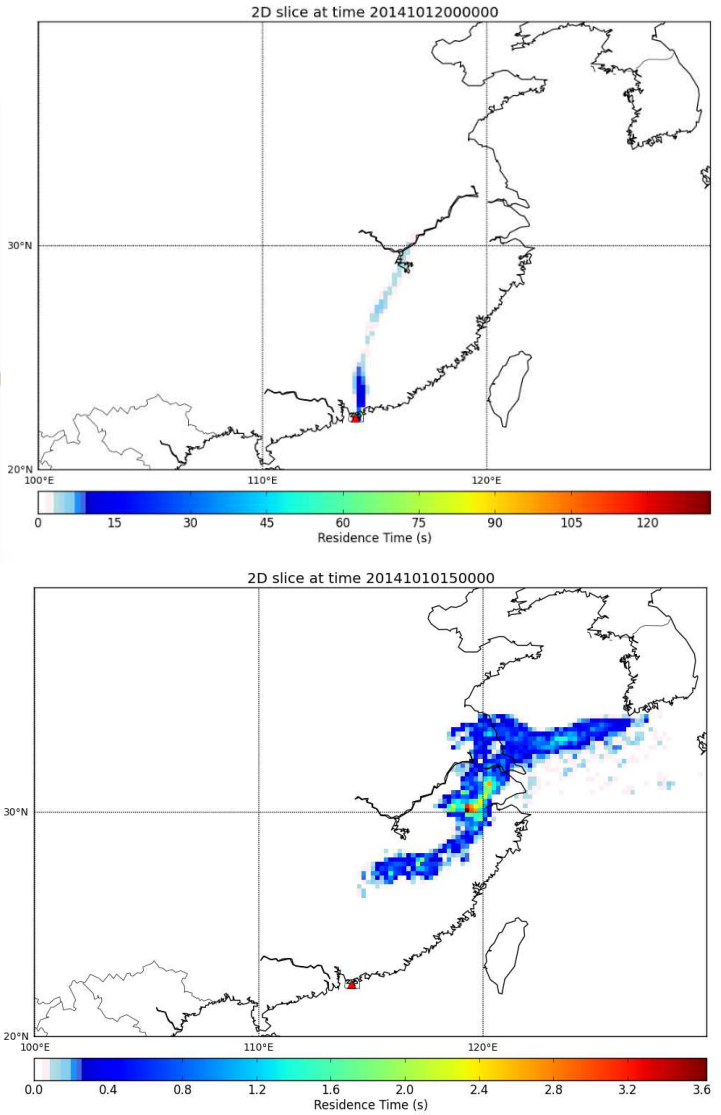
```
./plot_FLEX_binary.py ./output_NCEP/ False nuc1 0 0 alldates cyl False
100.0,130.0,20.0,40.0 mesh False
```



Is this discontinous plume evolution reasonable? Remember differences between COMPUTATIONAL domain and OUTGRID domain

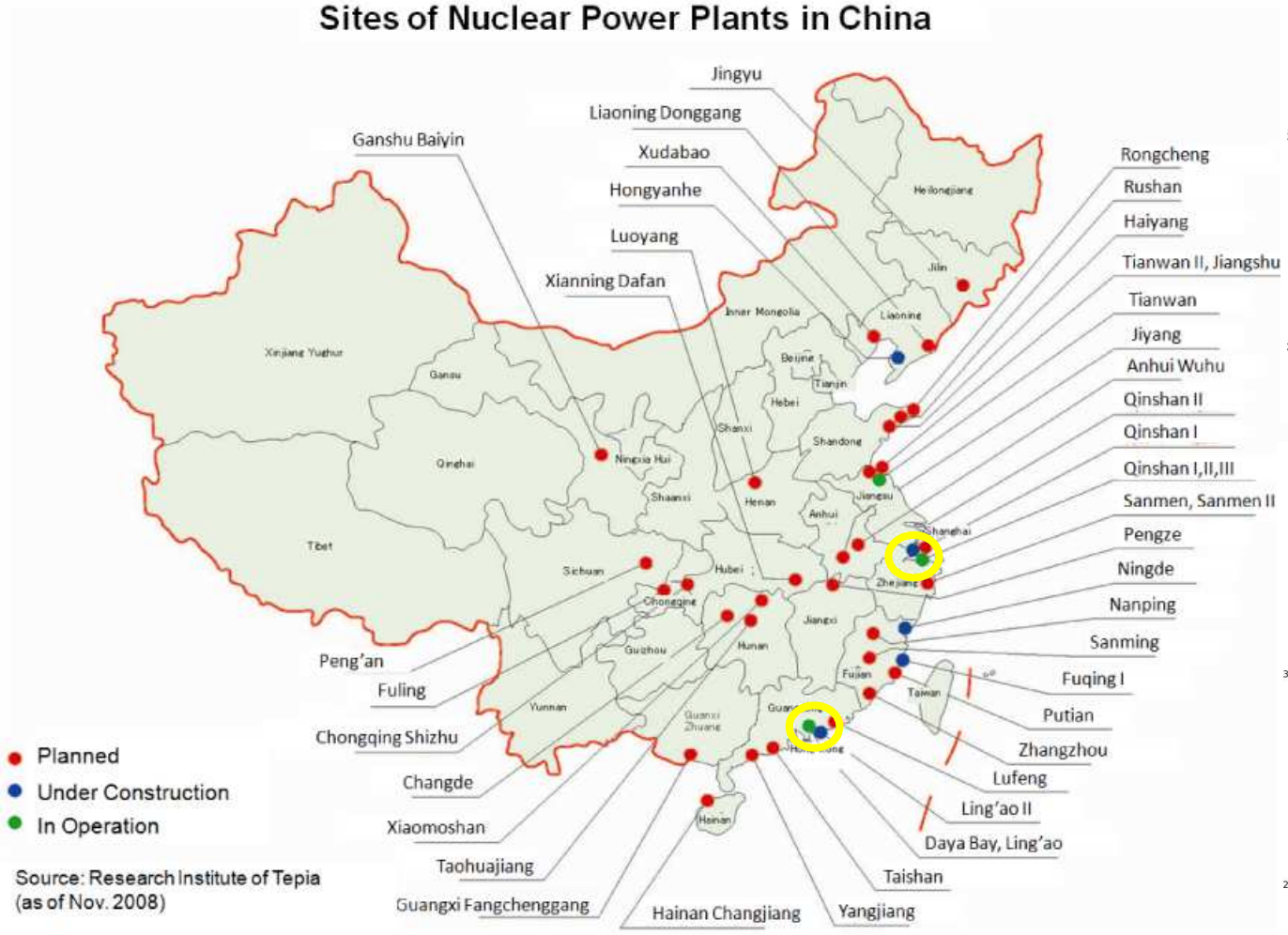
Bwd run from HKO

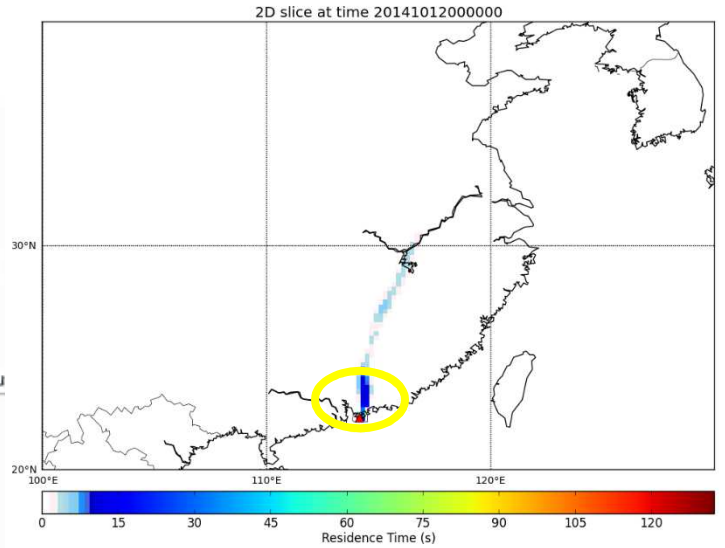


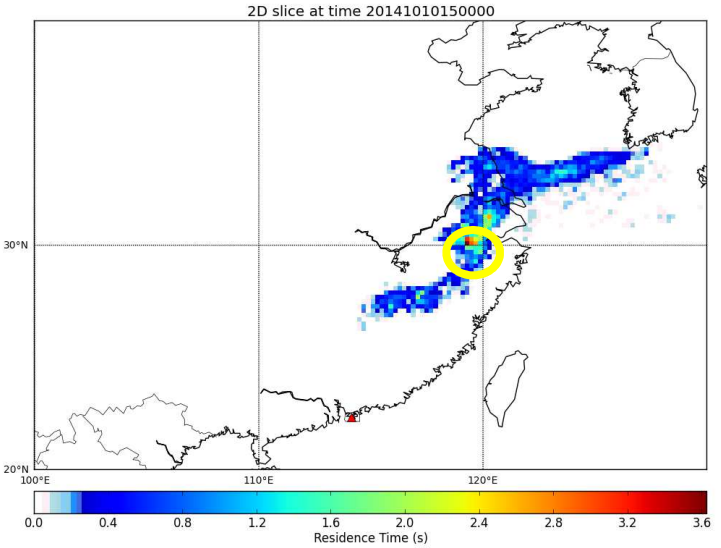


Do we have only one single potential contributing source?

Bwd run from HKO







What would be the sources that would have led to that measurement with respect to the results?

Bwd run from HKO

Observation = Emission * sensitivity to emission

$m[Bq/m^3] = M[s] * S[Bq/s*m^3]$

How many Bequerels (kg, ...) released?

Potential source 1 – Daya Bay

M?

How big is the grid size?

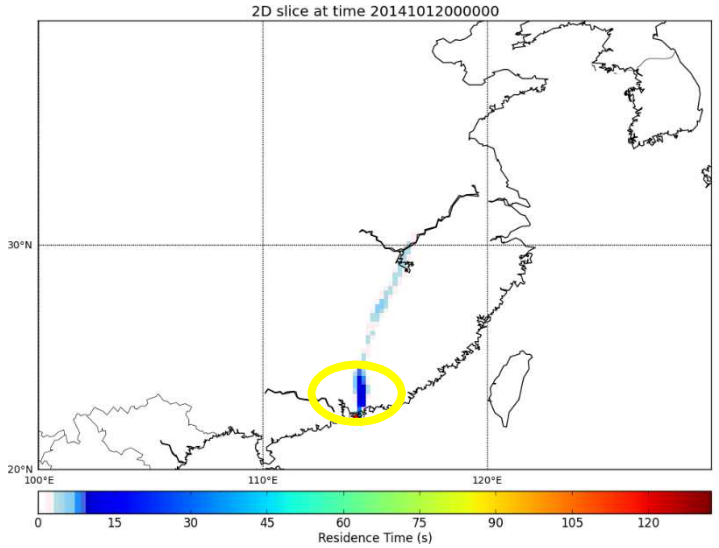
Which is the average timing? In what units?

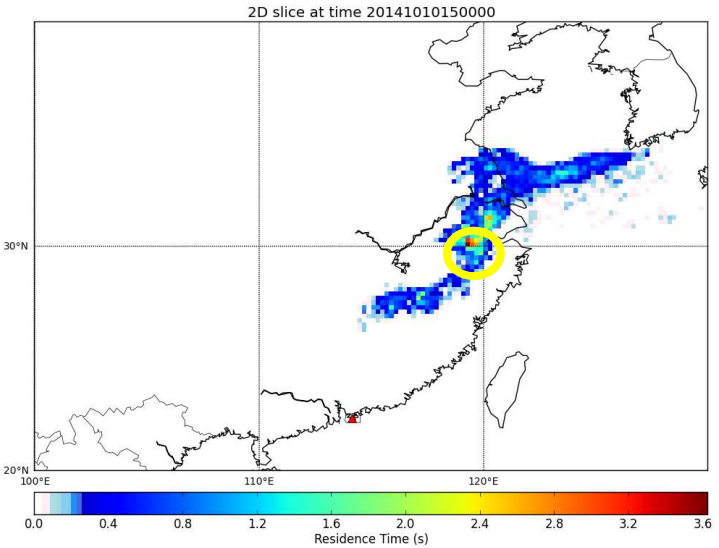
Potential source 2 – Qinshan

M?

How big is the grid size?

Which is the average timing? In what units?





What would be the sources that would have led to that measurement with respect to the results?

Bwd run from HKO

Observation = Emission * sensitivity to emission

$m[Bq/m^3] = M[s] * S[Bq/s*m^3]$

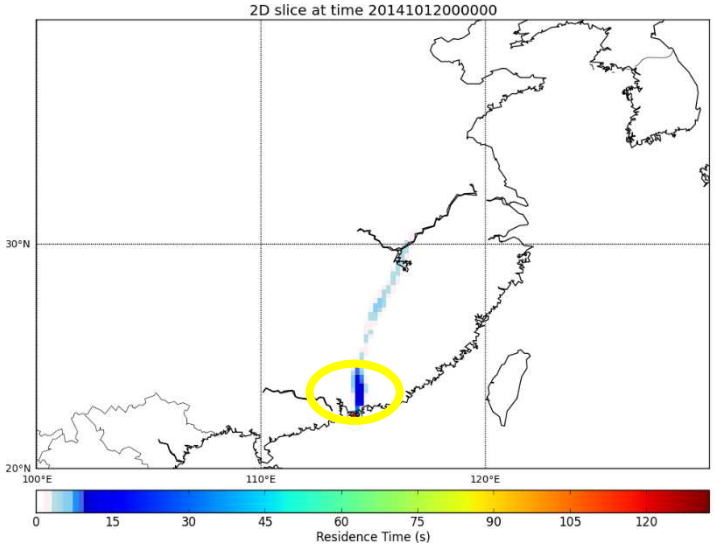
How many Bequerels (kg, …) released?

Potential source 1 – Daya Bay

M? 0.15 s

How big is the grid size? 0.2 x 0.2 deg x 150 (m)

Which is the average timing? In what units? 3 hours

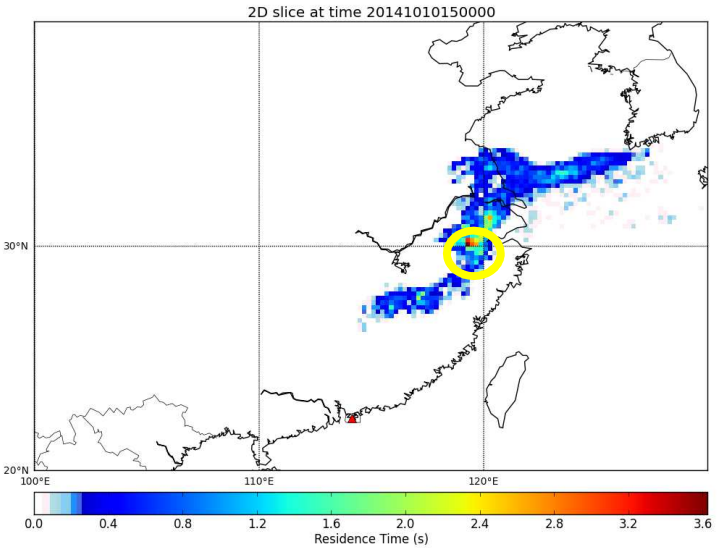


Potential source 2 – Qinshan

M?

How big is the grid size? 0.2 x 0.2 deg x 150 (m)

Which is the average timing? In what units? 3 hours



What would be the sources that would have led to that measurement with respect to the results?

Bwd run from HKO

Observation = Emission * sensitivity to emission
m[Bq/m³] = M[s] * S[Bq/s*m³]

How many Bequerels (kg, ...) released?

Potential source 1 – Daya Bay

M? 0.15 s

How big is the grid size? 0.2 x 0.2 deg x 150 (m)

Which is the average timing? In what units? 3 hours

S[Bq] = (m[Bq/m³]/M[s])*3*3600[s]*0.2*100000*0.2*100000*150[m³]
= 4x10**4[Bq/m3]* 1/M[s] *3 *3600[s] *0.2 *100000
*0.2*100000*150[m³] = 1.77E+20 Bq!

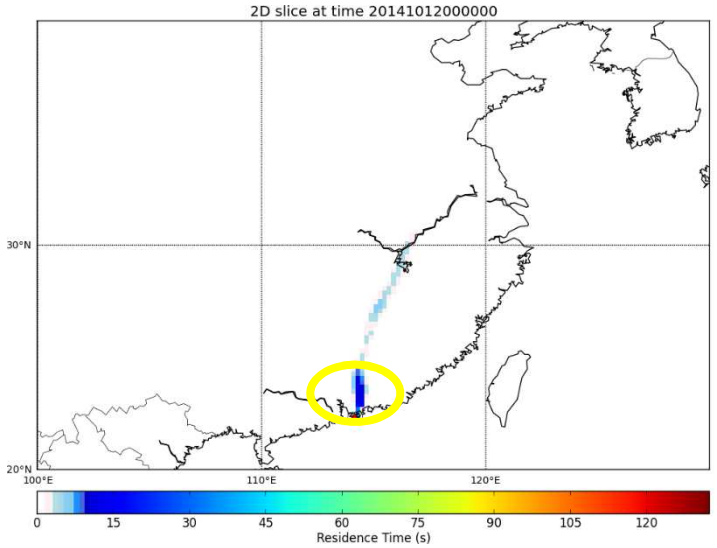
Potential source 2 – Qinshan

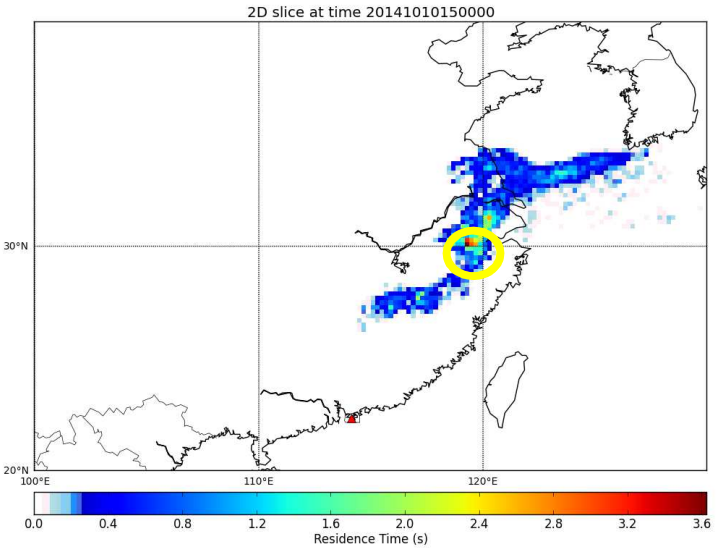
M? 3.5 s

How big is the grid size? 0.2 x 0.2 deg x 150 (m)

Which is the average timing? In what units? 3 hours

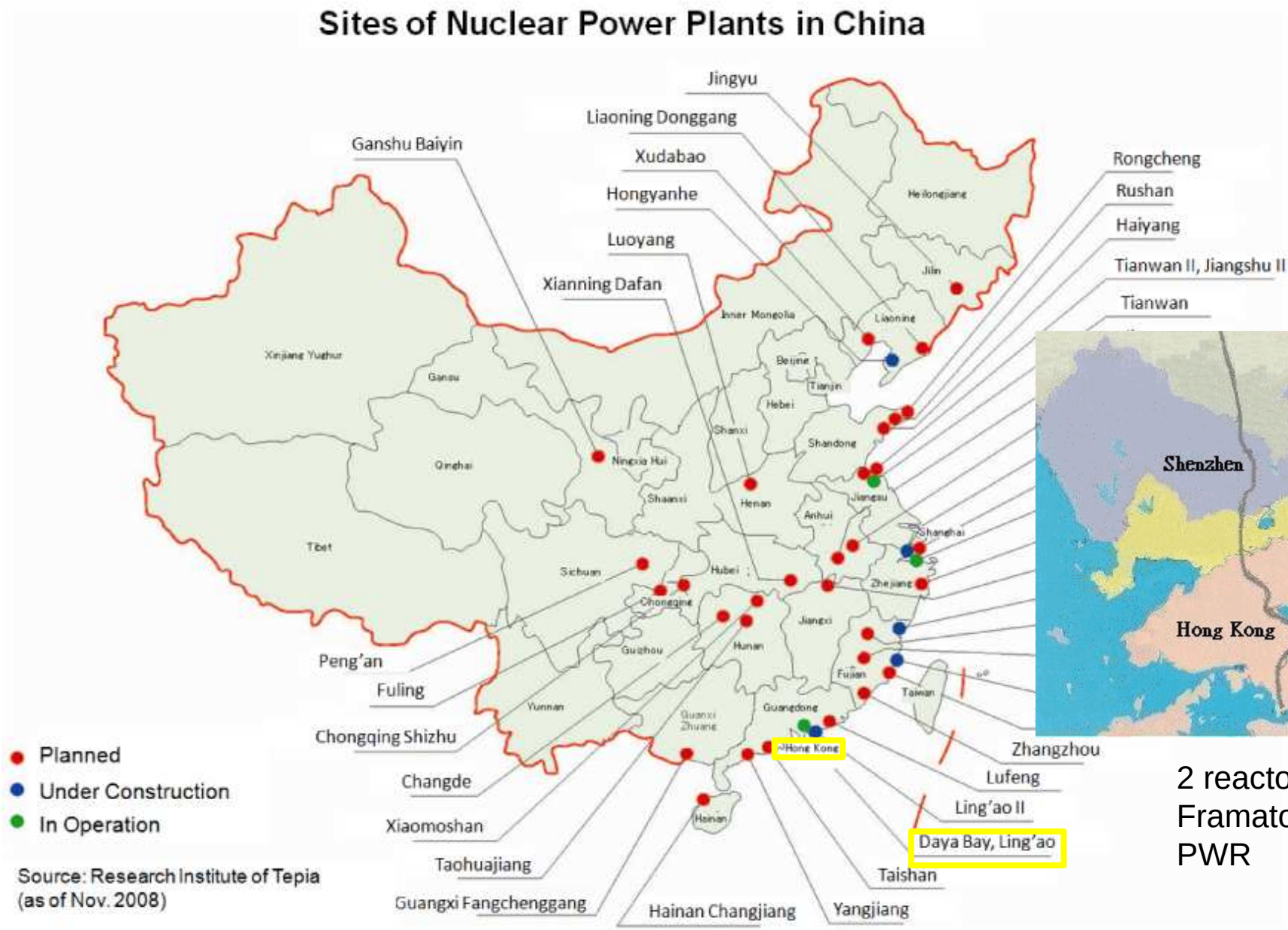
S[Bq] = (m[Bq/m³]/M[s])*3*3600[s]*0.2*100000*0.2*100000*150[m³]
= 4x10**4[Bq/m3]* 1/M[s] *3 *3600[s] *0.2 *100000
*0.2*100000*150[m³] = 7.41E+18 Bq!





?

GNPS Guangdong Daya Bay NPP



2 reactor units
Framatome 900 MWe
PWR

http://www.jsm.or.jp/ejam/Vol.1.No.3/GA/6/article.html

http://www.hko.gov.hk/education/dbcp/pow_stat/eng/r2.htm

GNPS NPP hypothetical scenario

Table 3.4-1 Hypothetical source term used in the contingency plan in Hong Kong

Source term GD	Probability (y^{-1})	Release time (h)	Release duration (h)	Height (m)	Release fraction						
					Xe,Kr	I	Cs	Te	Ba,Sr	Ru(1)	La(2)
1	3.00E-08	1.5	1	10	2.0	1.6	1.44	1.38	1.1E-1	6.6E-1	1.7E-2
2	5.60E-06	1.5	1	10	1.0	8.0E-1	7.2E-1	6.9E-1	5.6E-2	3.3E-1	8.7E-3
3	2.00E-07	2.5	1	10	1.0	1.8E-1	1.4E-1	1.4E-1	5.0E-2	5.8E-3	6.4E-4
4	2.60E-07	2.5	1	10	1.0	1.8E-1	1.4E-1	1.4E-1	5.0E-2	5.8E-3	6.4E-4
5	1.20E-06	1	10	10	1.0	1.8E-1	8.4E-2	3.6E-1	1.3E-1	2.0E-2	1.8E-3
6	4.00E-07	1	10	10	1.0	5.2E-2	1.7E-2	7.2E-2	2.6E-2	4.1E-3	3.6E-4
7	4.80E-05	12	1	10	1.0	1.7E-1	1.5E-1	2.4E-1	5.3E-2	4.2E-5	3.4E-3
8	6.00E-08	2.5	10	10	1.0	5.0E-2	3.0E-2	3.7E-2	2.1E-2	2.2E-3	8.9E-3
9	1.20E-06	24	1	0	1.0	1.7E-4	1.0E-4	9.7E-5	1.1E-5	8.9E-7	1.3E-7
10	1.20E-06	24	10	10	0.75	8.5E-3	3.5E-3	3.5E-3	4.0E-3	3.0E-4	5.0E-5
11	5.00E-06	1	2	0	1.0	6.7E-1	6.7E-1	6.4E-1	7.0E-2	5.0E-2	9.0E-3
12	3.60E-05	24	1	10	5E-3	1.2E-4	1.0E-4	9.7E-5	1.1E-5	8.9E-7	1.3E-7

(1) include Ru, Mo (2) include La,Y, Zr, Ce, Pu, Am, Cm

Source from:

Consultancy on the environment aspects of the Daya Bay Nuclear Power Station for the govern... Kong – Risk Assessment [16]

http://hub.hku.hk/bitstream/10722/41313/6/FullText.pdf

Hypothetical ST based on US Surry (Westinghouse) PWR due to similar design (not the same thermal power – scaling)

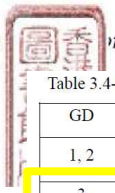


Table 3.4-2 Description of the source term used in the hypothetical accident

GD	Description
1, 2	Early overpressure due to direct heating, hydrogen explosion, or steam explosion effects, or combinations thereof, with high pressure core melt.
3	Early overpressure due to direct heating, hydrogen explosion, or steam explosion effects, or combinations thereof, with low or medium pressure core melt and sprays NOT operating.
4	Early overpressure due to direct heating, hydrogen explosion, or steam explosion effects, or combinations thereof, with low or medium pressure core melt and sprays operating.
5	Failure to isolate (large leakage rate), sprays NOT operating.
6	Failure to isolate (large leakage rate), sprays operating.
7	Overpressure due to failure of containment heat removal.
8	Delayed overpressure due to accumulation of incondensable gases, or delayed excessive steam generation (with containment heat removal operating)
9	Basemat penetration by core debris.
10	Deliberate (filtered) venting.
11	Bypass of the containment by direct connection of the primary circuit to the surroundings
12	Successful containment.

GNPS NPP hypothetical scenario

Table 3.5-1 Inventory in reactor of the nuclear power plant and half-lives

Nuclide	Initial inventory Q_T(Bq)	Half-lives $T_{1/2}$(s)
Kr-85	1.8490E+16	3.3860E+08
Kr-85m	7.9000E+17	1.6128E+04
Kr-87	1.4520E+18	4.5602E+03
Kr-88	1.9950E+18	1.0083E+04
Sr-89	2.8760E+18	4.4928E+06
Sr-90	1.4910E+17	8.8646E+08
Y-91	3.8550E+18	5.0553E+06
Zr-95	5.0260E+18	5.6592E+06
Mo-99	5.5000E+18	2.3760E+05
Ru-103	4.4810E+18	3.4206E+06
Ru-106	2.7210E+18	3.1795E+07
Te-129m	1.4230E+17	2.9030E+06
Te-131m	2.9620E+17	1.0800E+05
Te-132	4.1440E+18	2.8080E+05
I-131	2.8950E+18	6.9466E+05
I-132	4.2410E+18	8.2800E+03
I-133	5.8220E+18	7.4822E+04
I-134	6.6910E+18	3.1560E+03
I-135	5.4740E+18	2.3796E+04
Xe-133	5.8480E+18	4.5706E+05
Xe-135	1.4230E+18	3.3013E+04
Cs-134	3.2920E+17	6.5007E+07
Cs-136	1.1330E+17	1.1318E+06
Cs-137	1.9560E+17	9.4954E+08
Ba-140	5.2480E+18	1.1051E+06

RELEASES

RN	Inventory (Bq)	Rel. Frac.	Release (Bq)	Release (TBq)
Xe-133 NG	5.85E+18	1	5.85E+18	5.85E+06
Cs-137 aerosol	1.96E+17	0.14	2.74E+16	2.74E+04
I-131 (I2)	2.90E+18	0.18	2.61E+17	2.61E+05
I-131 aerosol			2.61E+17	2.61E+05

- Emission/release length : 1 hour starting at 20140923 00:00 UTC
- Emission/release height : 10 m a.g.l → 50 m a.g.l column (~ building height)
- Location: 22.5972° N , 114.5444° E

Multispecies release

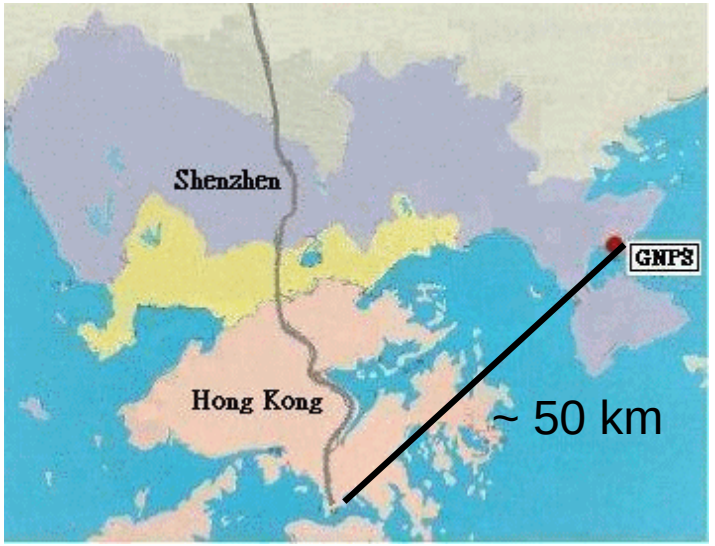
Mind:

- Gravitational settling
- Definition of each of the species
- Post-processing
- Number of particles per release (10000)

GNPS NPP hypothetical scenario

OUTGRID/OUTGRID_NEST

- Mother/Nest:
  - LLC -179.0° /112.5° E, -90.0° /21.0° N
  - 360 x 180 / 320 x 320
- Vertical levels
  - 1000, 2000 and 5000 m a.g.l
- Horizontal resolution mother/nest: 1.0° x 1.0° / 0.01° x 0.01°



COMMAND

- Simulation start / stop: 20140923 00:00 UTC / 20140923 12:00 UTC
- Temporal resolution: hourly
- LCONVECTION=1, IOUT=0, NESTED_OUTPUT=1

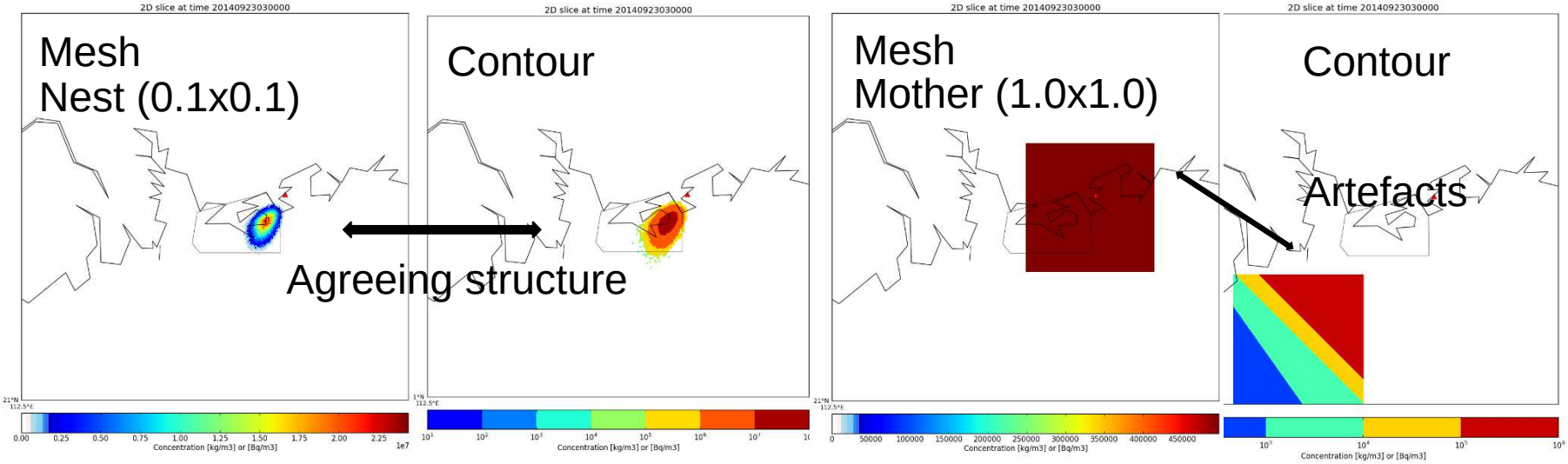
ECMWF (1.0° /0.2° nested) & GFS (0.5°) meteorological data

GNPS NPP hypothetical scenario

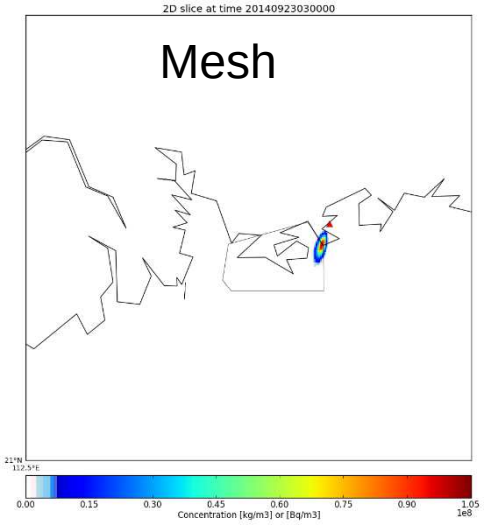
Results for Xe-133 (non-depositing)

High-resolution nest needed in the near-range!

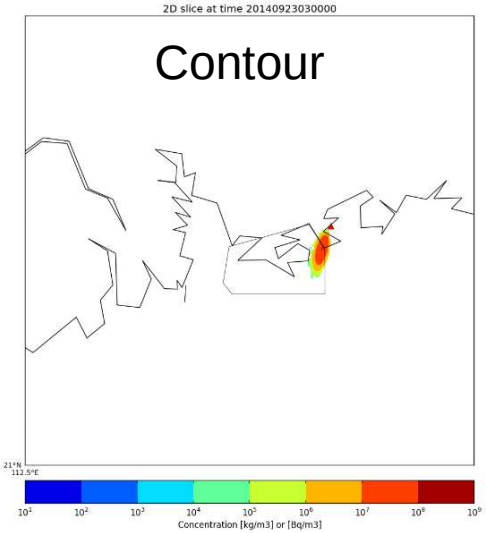
ECMWF:



NCEP:

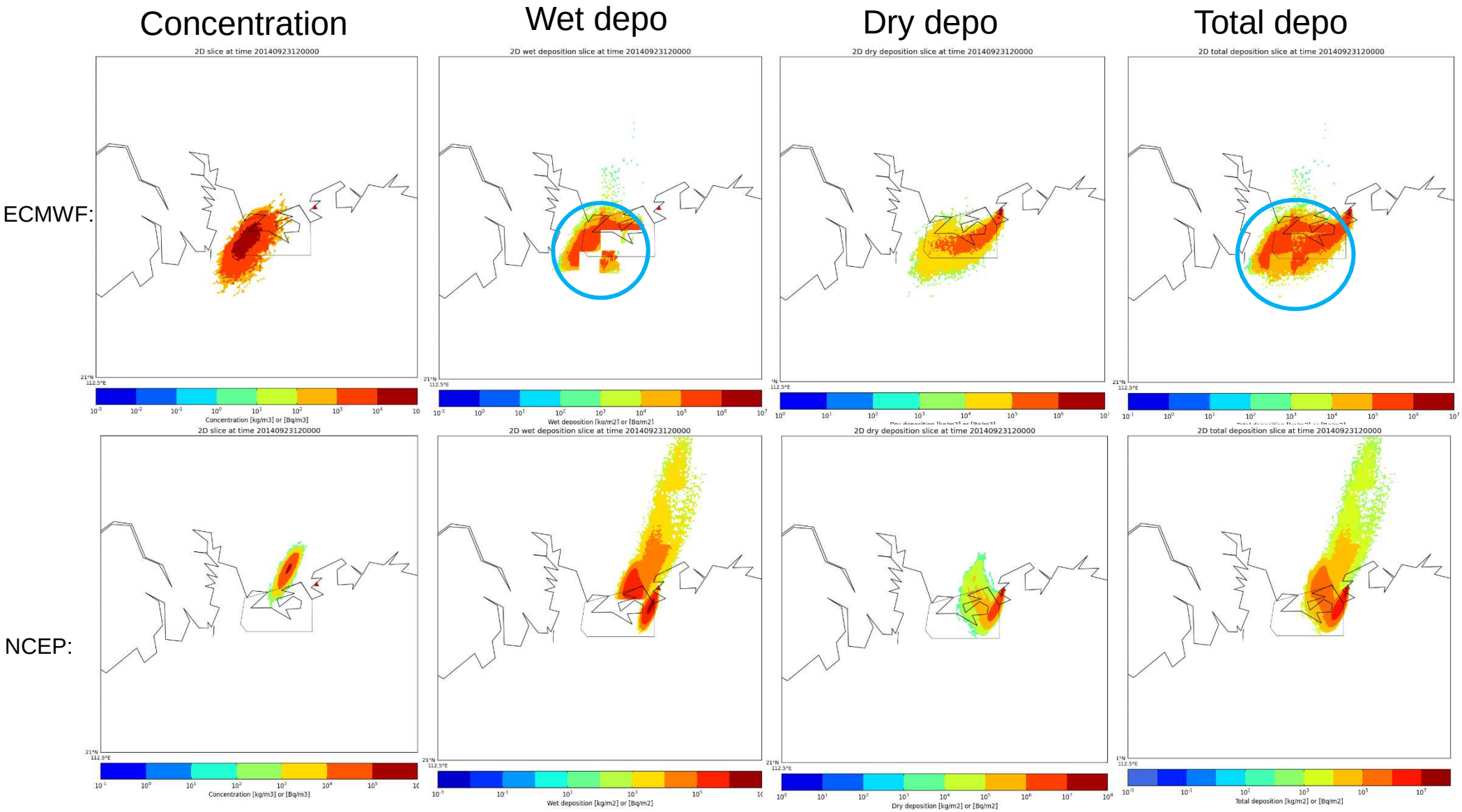


./plot_FLEX_binary.py ./output_ECMWF [NCEP]/ True [False] 4 0 3 alldates cyl False 112.5,115.5,21.0,24.0 mesh [contour] False



GNPS NPP hypothetical scenario

Cs-137 aerosol:



./plot_FLEX_binary.py ./output_ECMWF[NCEP]/ True 3 0 0 alldates cyl True 112.5,115.5,21.0,24.0 contour False