THAILAND

Progress and Challenges of 2017 Benchmark Problem Assessment

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สถาบันเทคโนโลยีนิวเคลียร์แห่งชาติ (องค์การมหาชน)
Thailand Institute of Nuclear Technology (Public Organization)

Our Team

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  - Piyatida Trinuruk

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Proposed 2017 Benchmark Problem

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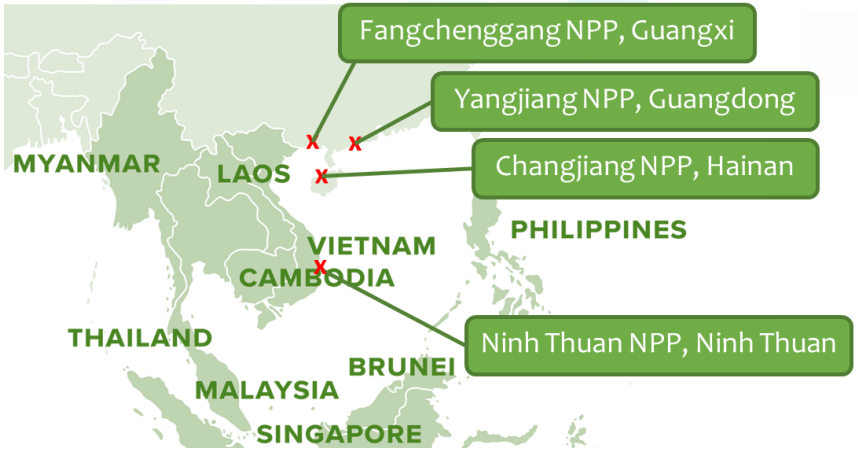
Location

- Place(s) where local meteorological data can be obtained
- Place(s) where at least two Participating Member States choose to assess will be selected as the location for the benchmark problem
- Potential sites for NPP
  - (Ninh Thuan)
  - Fangchenggang
  - Changjiang
  - Yangjiang



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Core Inventory

- Passed preference of the region
  - Generation III reactors
  - APWR

- Thailand's suggestion
  - Normalizing the core inventory at the end of the cycle (EOC) for a PWR reactor (3,412 MWth) suggested in NUREG/ CR-6094 to 1,100 MWe (approx. 3,300 MWth)

Source Term

- Accident scenario
  - Select out of those for Surry Nuclear Power Plant (Surry NPP) in the SOARCA project (NUREG-7110)
  - Unmitigated scenario of the long-term station blackout (long-term SBO; similar to that in 1F NPP)
  - Radionuclides: iodine-131, cesium-137
  - Release amount: 1% each
  - Release starting time: 24 hr
  - Release period: 24 hr

Meteorological Data

- Hourly data of all scales for a specific year is needed*.
  - Speed (m/s) and the direction (32 or 16 directions) of the surface wind and/or those at different geopotential heights
  - Rainfall (mm/h)
  - Vertical temperature profile (to determine the Richardson number) and/or the weather stability class
- Use multiple points of meteorological data to perform a two-dimensional calculation, if possible.

*Discussion is still needed on the appropriateness of the interval of the data and the total period of the data.

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Dose Calculation

- Early exposure shall include:
  - Cloudshine
  - Groundshine
  - Inhalation
- Chronic exposure shall include:
  - Groundshine
  - Resuspension
  - Ingestion
- No emergency response (can consider later)

Results to be Compared

- Radii for comparison
  - 5 km, 8 km (5 miles), 10 km, 16 km (10 miles), 20 km, 30 km, 50 km, 80 km (50 miles), 100 km, 200 km, 300 km and 500 km
- Items to be compared
  - Air concentration (Bq/m^3)
  - Ground concentration (Bq/m^2)
  - TEDE (Sv)
  - Dispersion pattern
  - Lead time until the radioactive plume reaches the border of the neighboring countries (h)

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Progress

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Calculation code

- HotSpot 2.07.2
- Why HotSpot?
  - Free of charge
  - Easy to understand
  - Simple assumptions
  - Require limited effort
  - **Suitable for newcomers**

*Thailand is planning for an assessment by Nuclear Accident Consequence Assessment Code (NACAC)

Scenario

- Accident sequence: long-term station blackout (long-term SBO)
- Location: Ninh Thuan, Fangchenggang, Changjiang, Yangjiang
- Reactor type: typical 1100 MWe PWR
- Source term
  - Release amount: I-131 (1%), Cs-137 (1%)
  - Release starting time: immediate
  - Release period: 24 hr
- Meteorological data: (Single) point hourly data (1 year; 2015) of wind speed, wind direction, rainfall and weather stability class, obtain from National Oceanic and Atmospheric Administration (NOAA)
- Exposure pathways: cloudshine, groundshine, inhalation
- Results: TEDE, dispersion pattern

Semi-Probabilistic Evaluation

- All 8,760 meteorological sequences are used for the assessment.
  - To cover hourly/season changes of the weather
- Representative values
  - 50^{th} percentile
  - 90^{th} percentile
  - 95^{th} percentile
  - 99^{th} percentile
- Can cover both most probable and extreme cases

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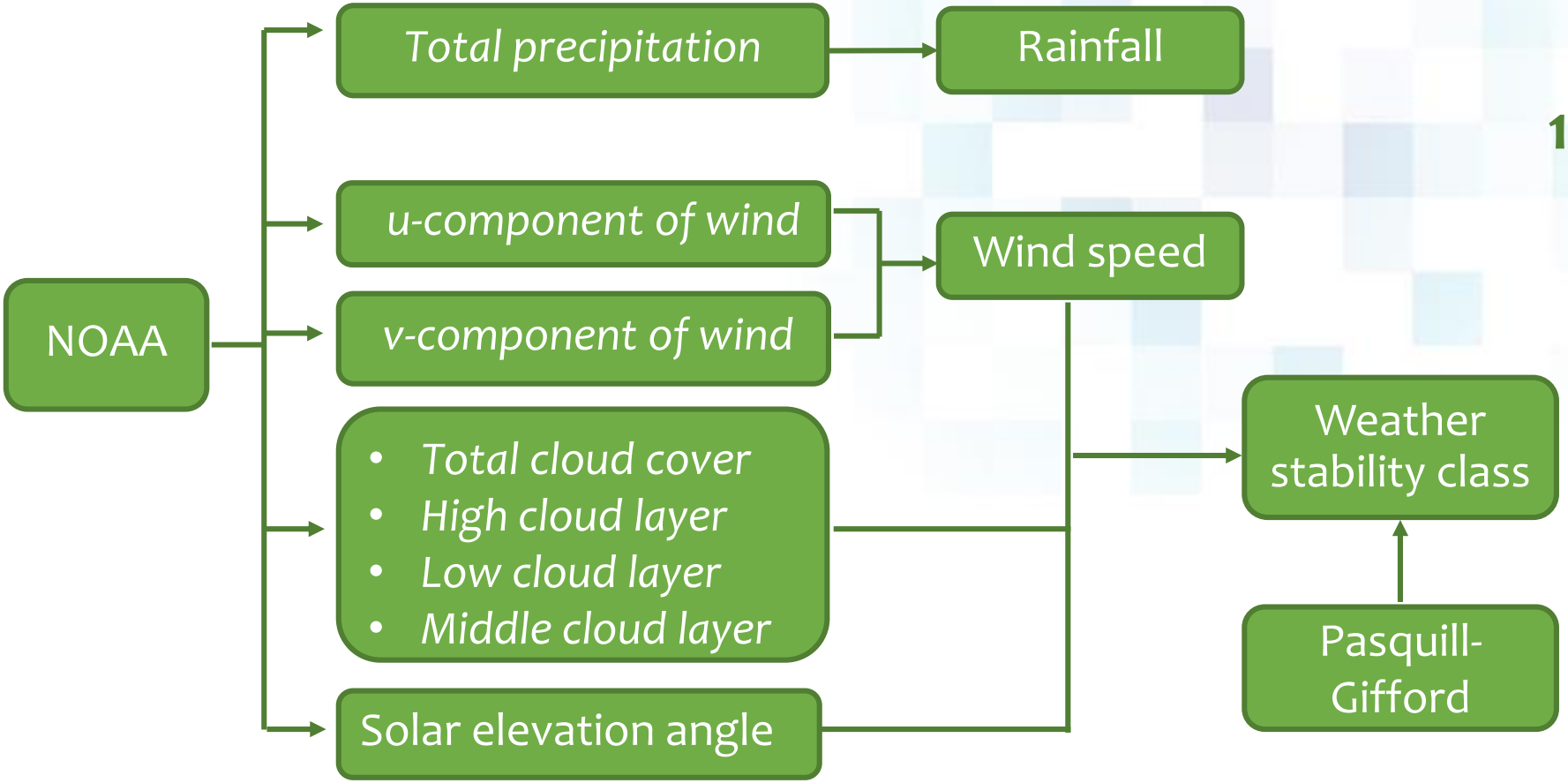
Meteorological Data



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(Pseudo) Sequential Puff-Trajectory Model

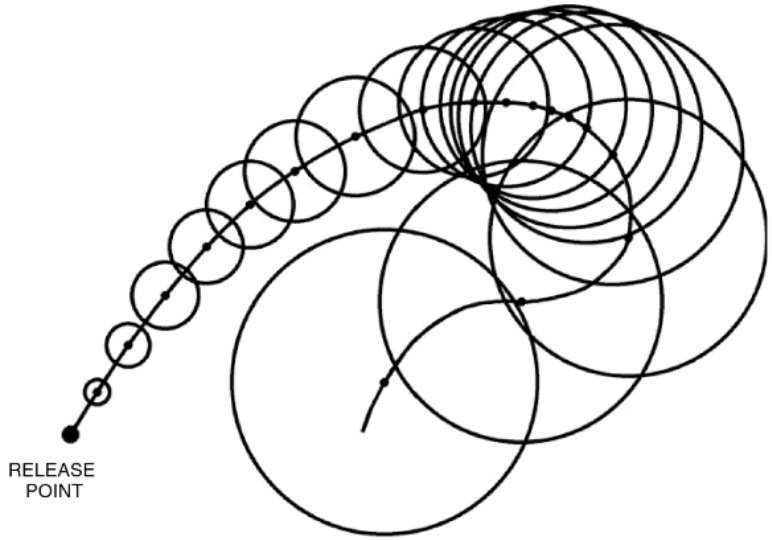
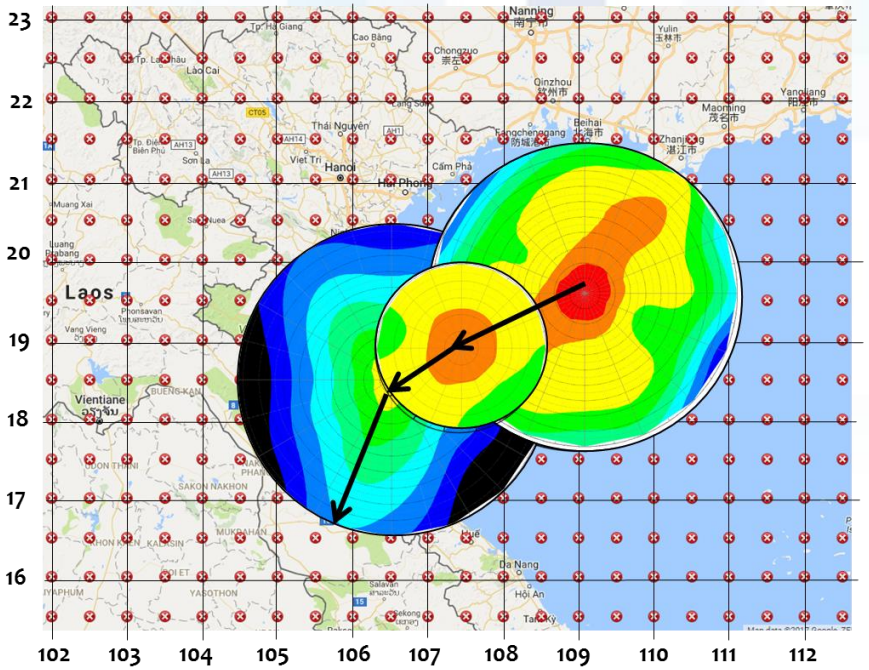


Figure 3.21 Simulation of a plume composed of a series of puffs released at equal time intervals and $\sigma \propto t$ (Hanna et al. 1982).



Ideal **Reality**

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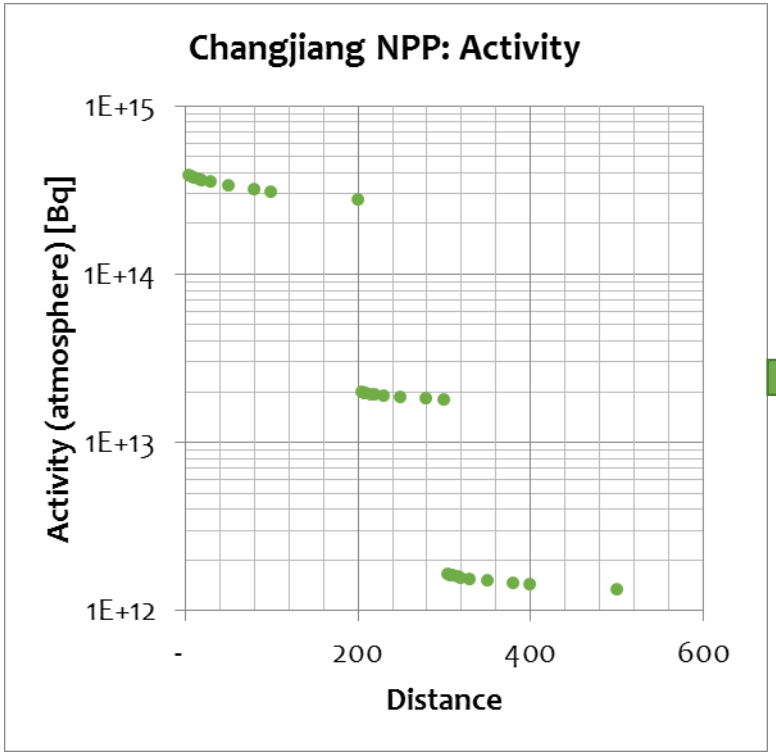
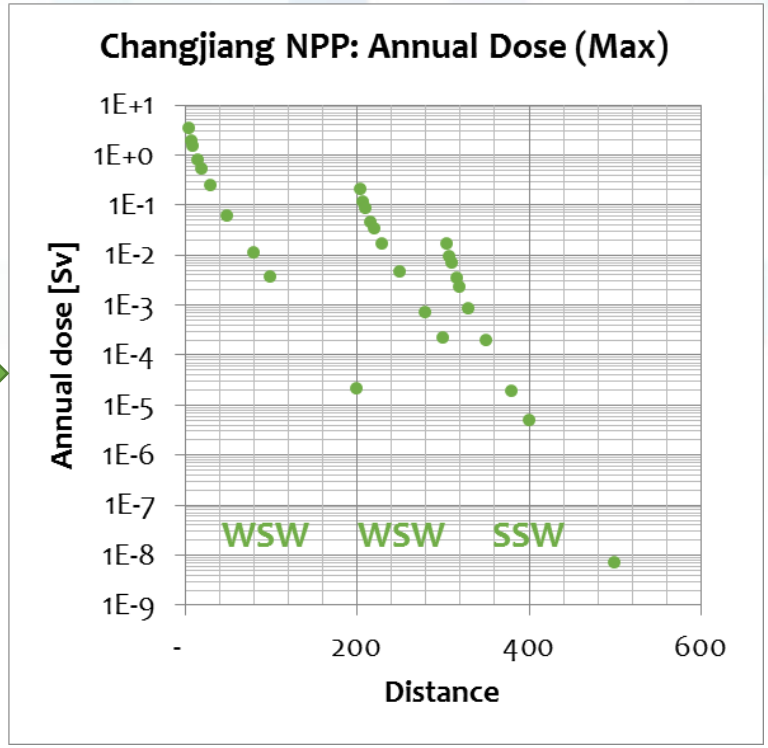
How did we calculate?





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Why didn't we move to a more sophisticated code?

- Free of charge
- Easy to understand
- Simple assumptions
- Require limited effort
- **Suitable for newcomers**

*Thailand is planning for an assessment by Nuclear Accident Consequence Assessment Code (NACAC)

Things we could calculate

- Radii for comparison
  - 5 km, 8 km (5 miles), 10 km, 16 km (10 miles), 20 km, 30 km, 50 km, 80 km (50 miles), 100 km, 200 km, 300 km and 500 km
- Items to be compared
  - Air concentration (Bq/m^3)
  - Ground concentration (Bq/m^2)
  - TEDE (Sv)
  - Dispersion pattern
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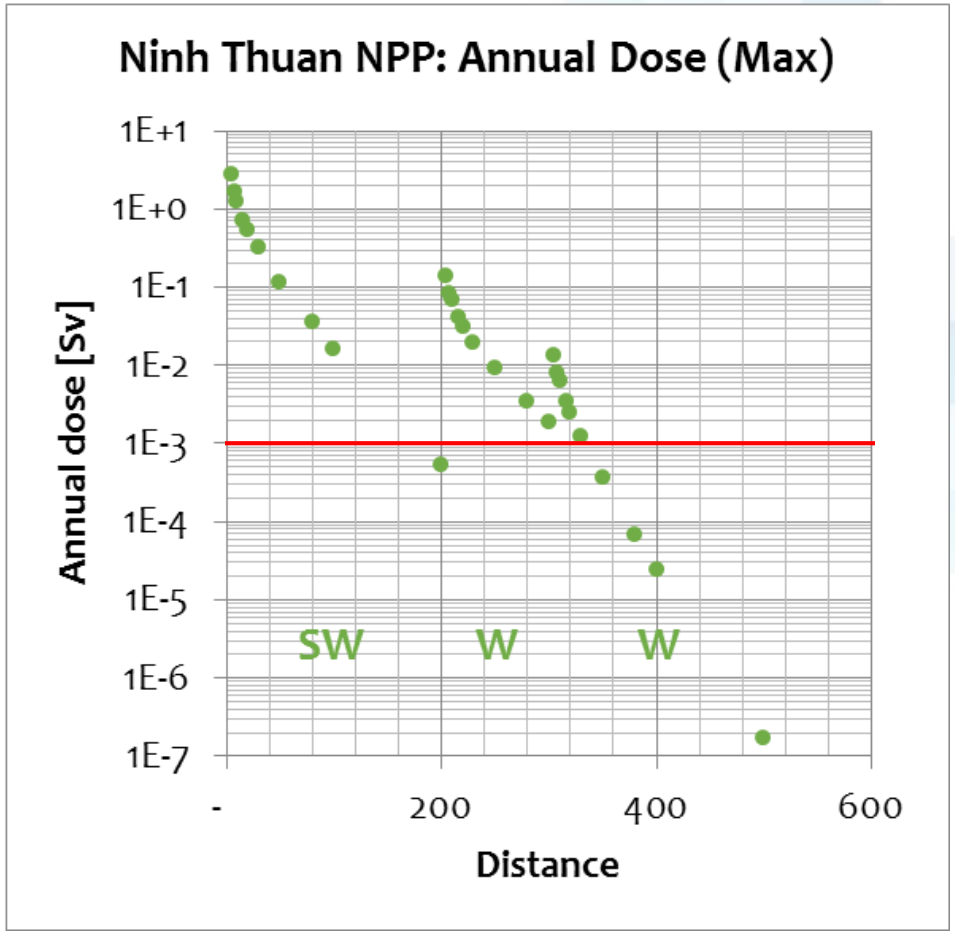
TEDE: Ninh Thuan



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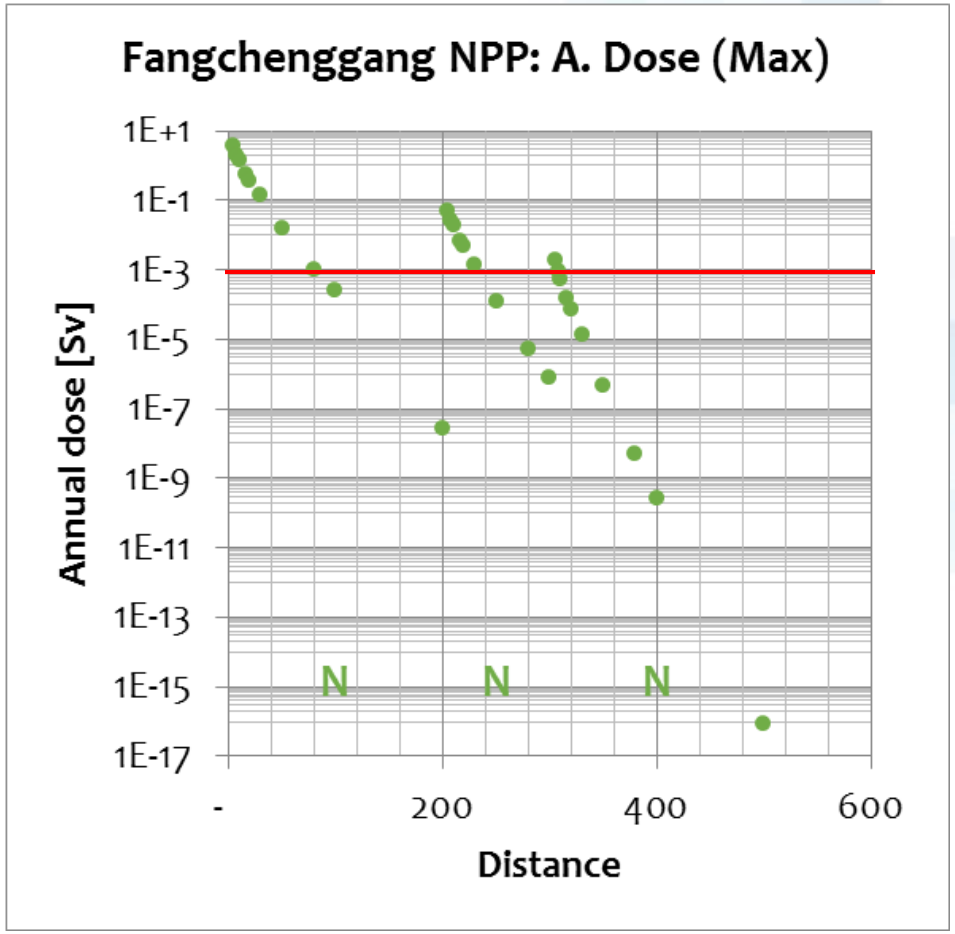
TEDE: Fangchenggang



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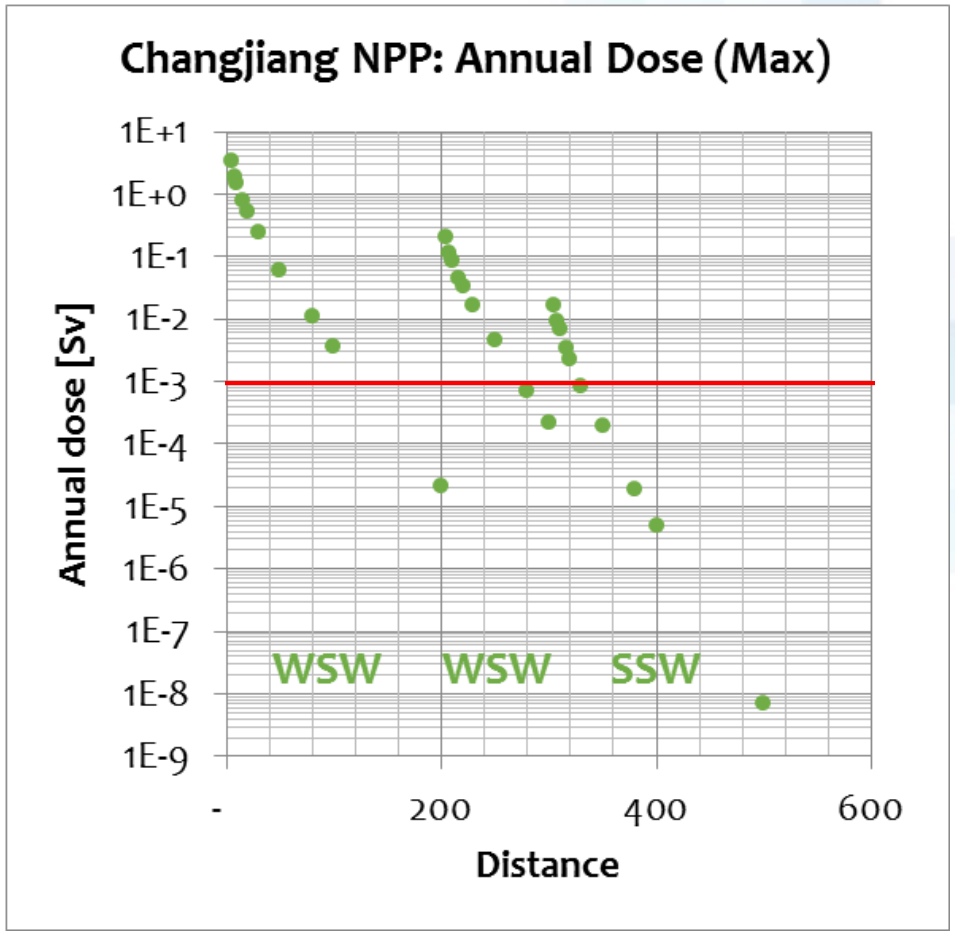
TEDE: Changjiang



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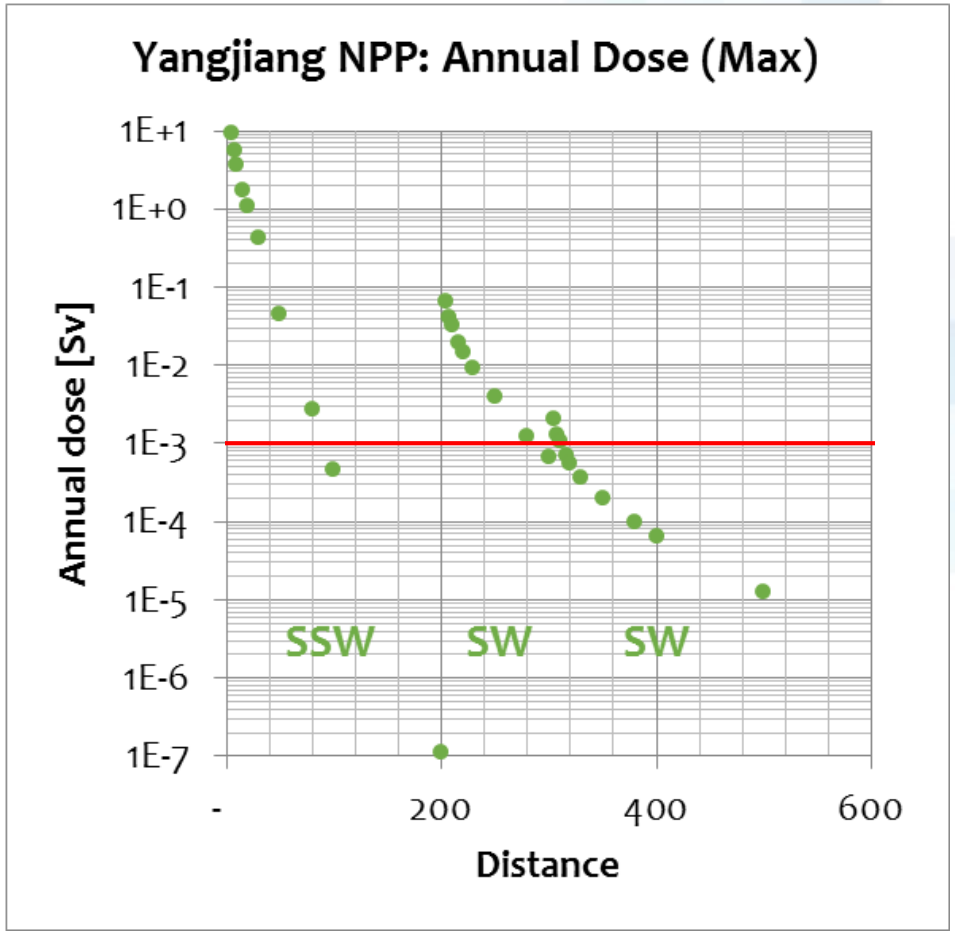
TEDE: Yangjiang



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TEDE: Summary

Distance	Ninh Thuan	Fangchenggang	Changjiang	Yangjiang
Direction	SW, W,W	N,N,N	WSW,WSW,SSW	SSW,SW,SW
5	2.72E+00	3.87E+00	3.49E+00	9.53E+00
8	1.62E+00	2.07E+00	1.89E+00	5.52E+00
10	1.26E+00	1.48E+00	1.47E+00	3.74E+00
16	7.12E-01	5.66E-01	8.02E-01	1.77E+00
20	5.40E-01	3.63E-01	5.10E-01	1.10E+00
30	3.17E-01	1.35E-01	2.43E-01	4.20E-01
50	1.13E-01	1.49E-02	6.11E-02	4.50E-02
80	3.59E-02	9.94E-04	1.09E-02	2.75E-03
100	1.58E-02	2.60E-04	3.72E-03	4.72E-04
200	5.33E-04	2.68E-08	2.18E-05	1.12E-07
300	1.91E-03	7.50E-07	2.14E-04	6.73E-04
500	1.72E-07	8.61E-17	6.86E-09	1.26E-05

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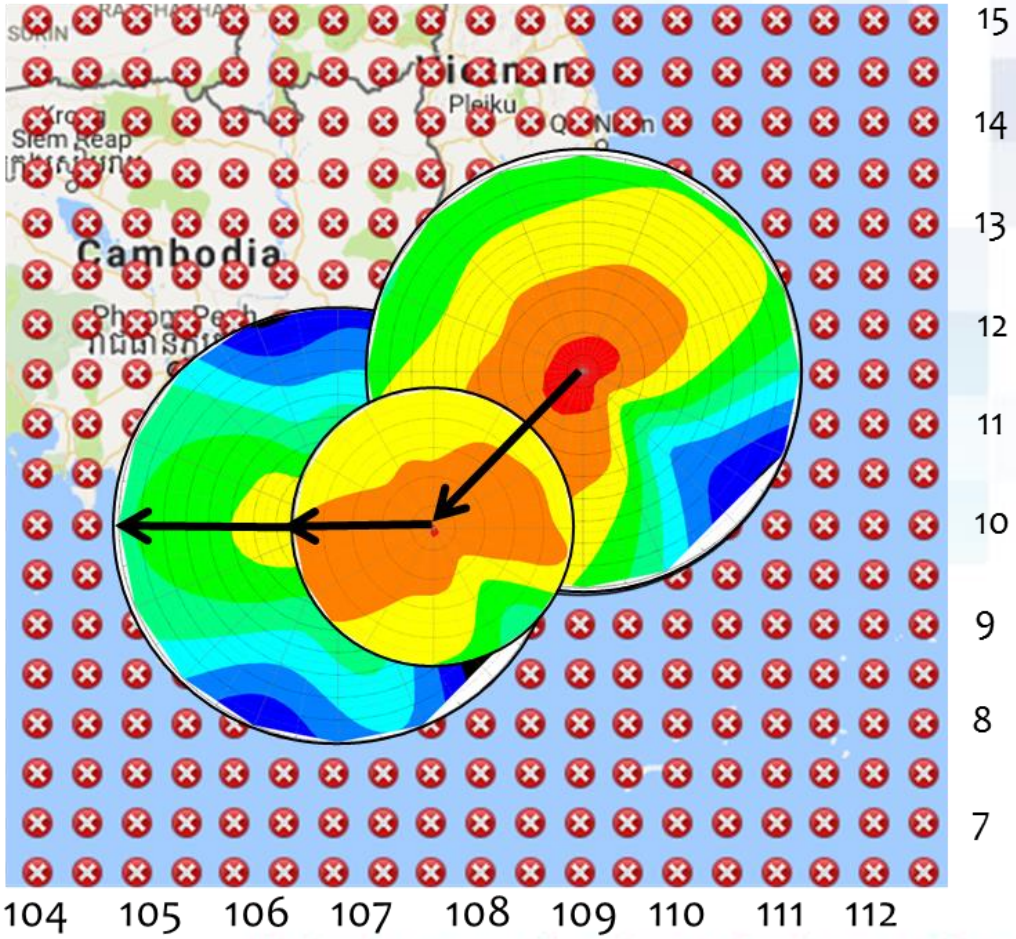
Dispersion Pattern: Ninh Thuan



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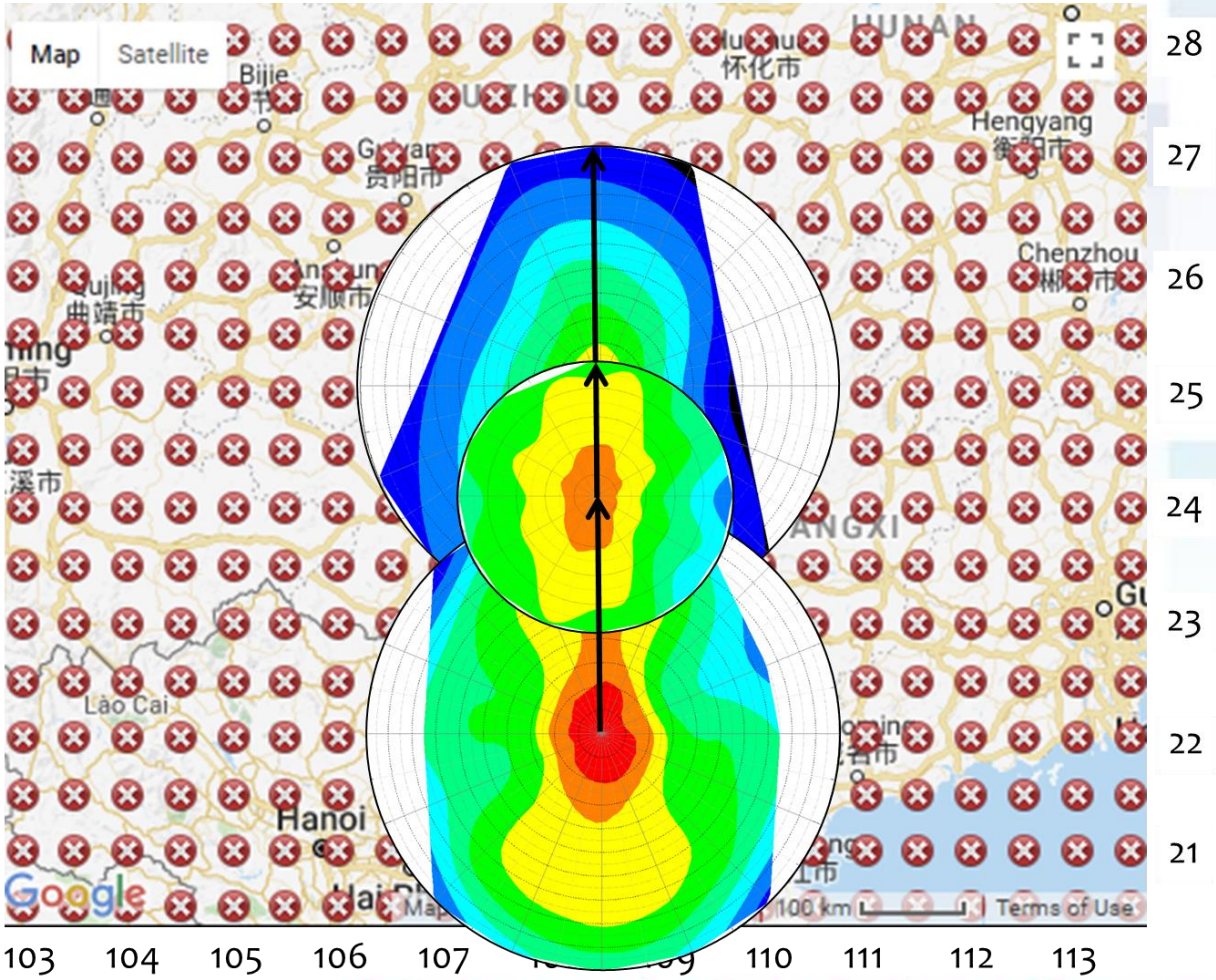
Dispersion Pattern: Fangchenggang



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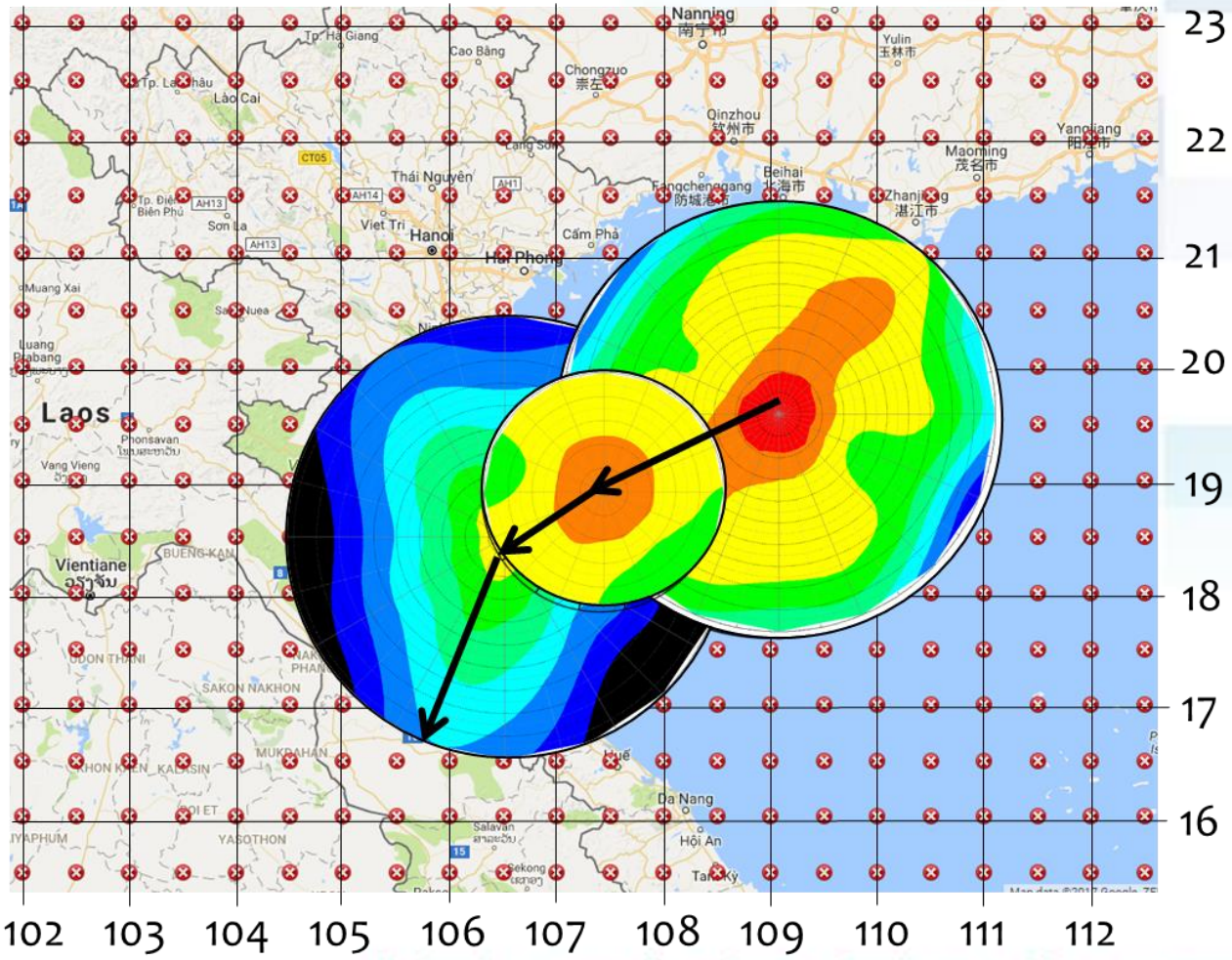
Dispersion Pattern: Changjiang



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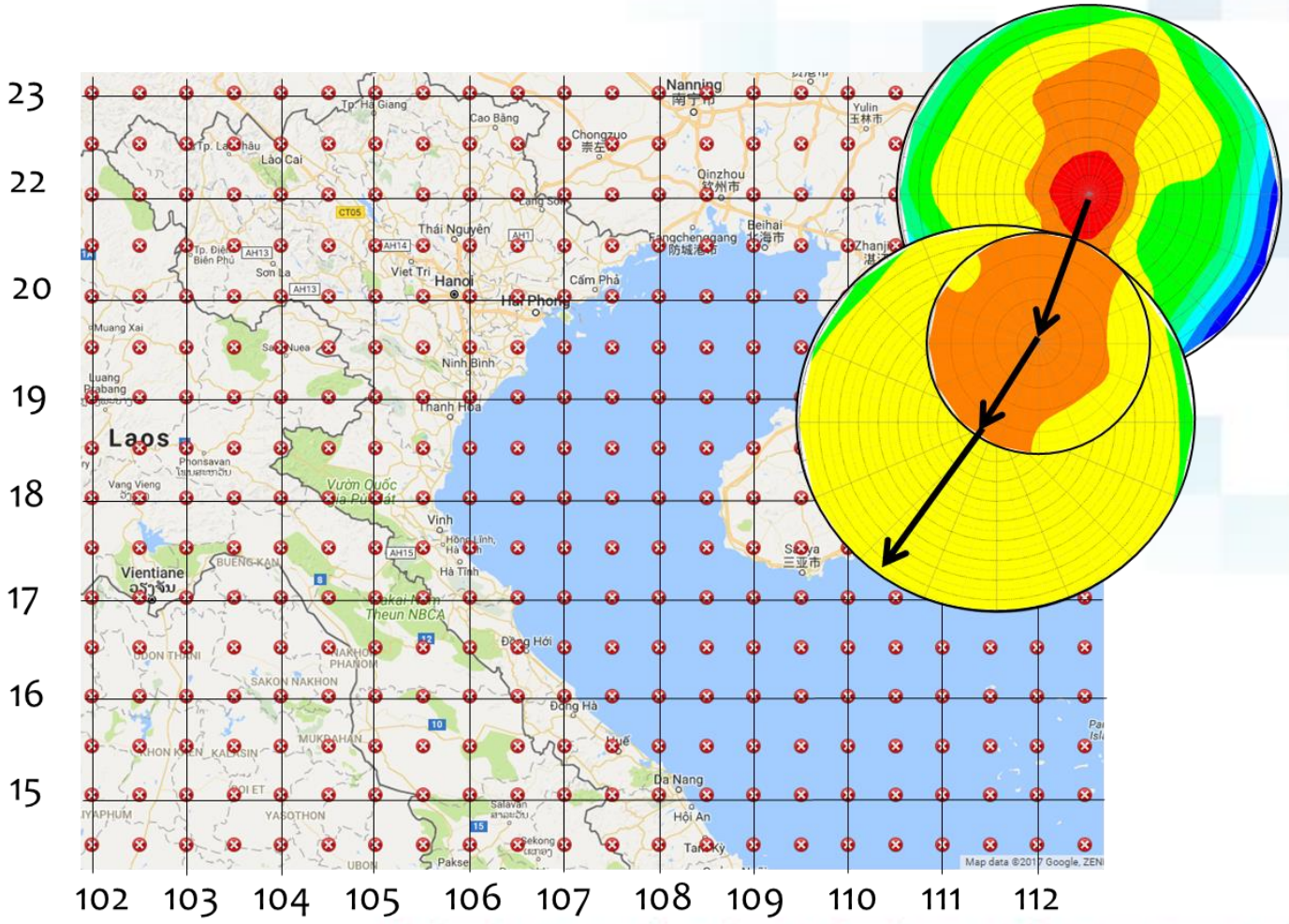
Dispersion Pattern: Yangjiang



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Assessment without a Calculation Code: Scoring based on Meteorological Data

Average value x Probability

Distance	Wind	Rain	Stability
N	10.6	1.63	14.5
NNE	22.3	3.24	25.3
NE	39.8	2.66	41.1
ENE	38.8	0.97	41.8
E	26	0.53	38.5
ESE	10.7	0.12	28.3
SE	8.38	0.19	23.9
SSE	16.5	0.15	32
S	31	0.56	40.7
SSW	29.5	1.55	30.2
SW	25.4	0.45	24.3
WSW	5.56	0.88	10.2
W	3.98	0.9	7.62
WNW	3.86	0.32	8.42
NW	7.46	0.73	12.8
NNW	10.8	1.36	15.4

Scoring criteria of atmospheric dispersion

Scoring criteria of atmospheric dispersion			
Wind speed	Rainfall	Stability	Score
0.00 - 4.77	2.16 - 3.24	0.00 - 9.32	1
4.78 - 7.46	1.56 - 2.15	9.33 - 12.76	2
7.47 - 9.48	1.18 - 1.55	12.77 - 14.99	3
9.49 - 10.66	0.91 - 1.17	15.00 - 23.89	4
10.67 - 13.65	0.81 - 0.90	23.90 - 24.83	5
13.66 - 22.30	0.57 - 0.80	24.84 - 28.28	6
22.31 - 25.70	0.50 - 0.56	28.29 - 31.08	7
25.71 - 29.45	0.33 - 0.49	31.09 - 38.45	8
29.46 - 34.88	0.18 - 0.32	38.46 - 40.88	9
34.89 - 39.82	0.00 - 0.17	40.89 - 41.75	10

Criteria is determined based on percentile values

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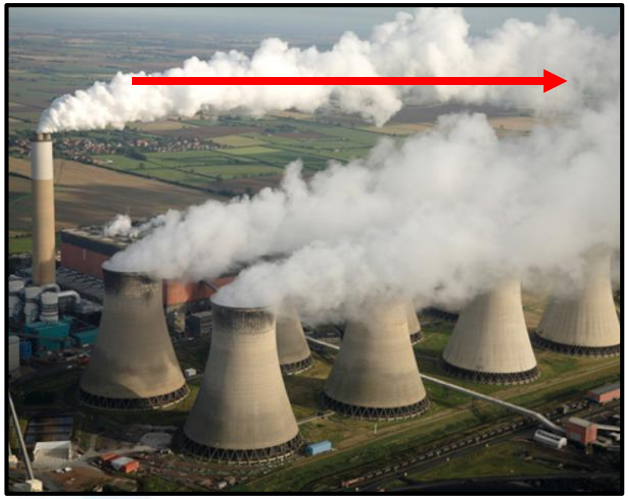
Example of Scoring

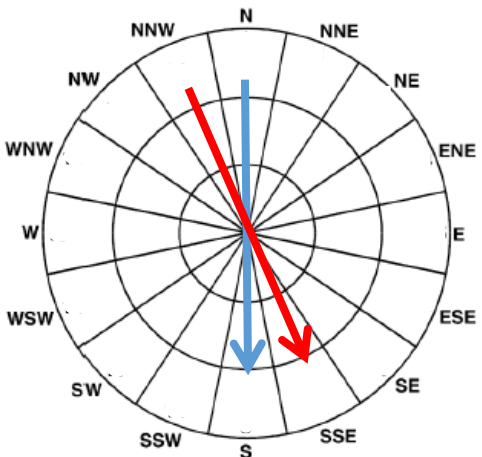
Scoring criteria of atmospheric dispersion			
Wind speed	**Rainfall**	**stability class**	**Score**
0.00 - 4.77	2.16 - 3.24	0.00 - 9.32	1
4.78 - 7.46	1.56 - 2.15	9.33 - 12.76	2
7.47 - 9.48	1.18 - 1.55	12.77 - 14.99	3
9.49 - 10.66	0.91 - 1.17	15.00 - 23.89	4
10.67 - 13.65	0.81 - 0.90	23.90 - 24.83	5
13.66 - 22.30	0.57 - 0.80	24.84 - 28.28	6
22.31 - 25.70	0.50 - 0.56	28.29 - 31.08	7
25.71 - 29.45	0.33 - 0.49	31.09 - 38.45	8
29.46 - 34.88	0.18 - 0.32	38.46 - 40.88	9
34.89 - 39.82	0.00 - 0.17	40.89 - 41.75	10

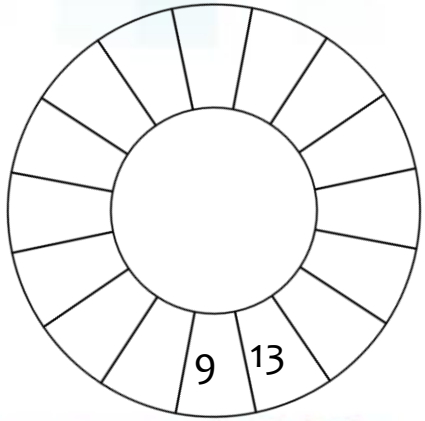
Direction	**Changjiang**		
	Wind speed (m/s)	Rainfall (mm/h)	Stability
N	10.58	1.63	14.54
NNE	22.3	3.24	25.32

Direction	**Scores**			**Total score**
	Wind speed	Rainfall	Stability	
N	4	2	3	9
NNE	6	1	6	14



Higher score implies better dispersion





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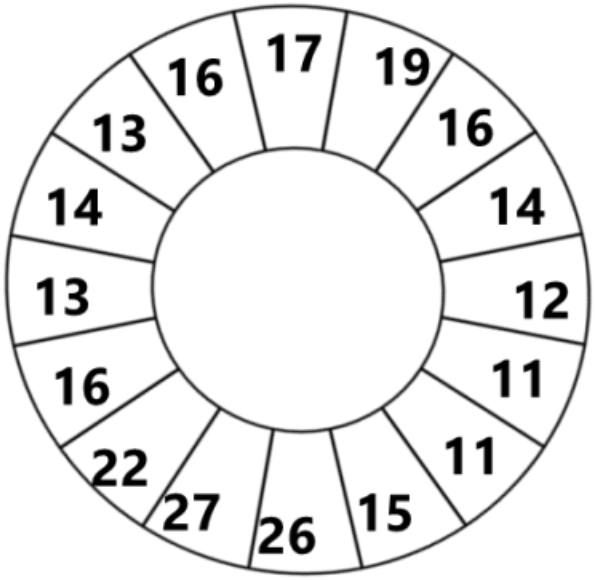
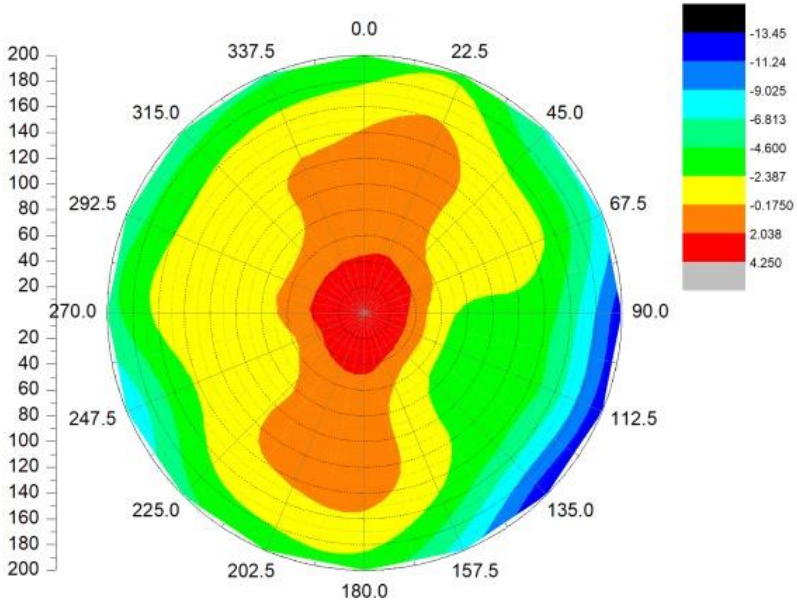
Scoring vs HotSpot

Changjiang (0 – 200 km)



Scoring



Result of HotSpot

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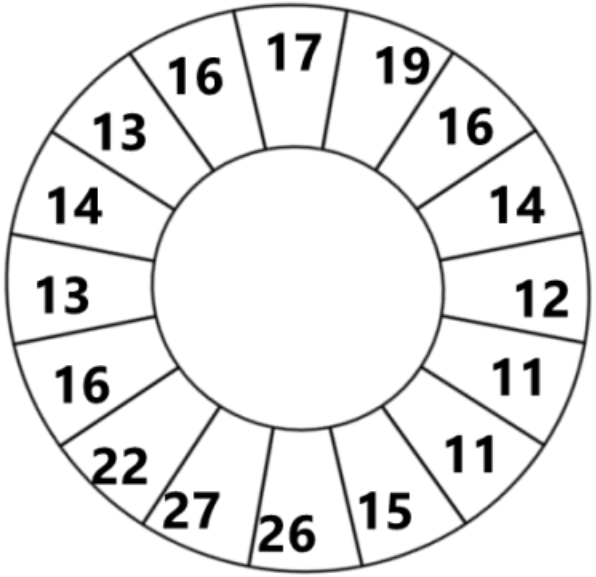
Scoring + (pseudo) Sequential Puff-Trajectory Model

Issue: How to **SIMPLY** convert activity (Bq) to dose (Sv)



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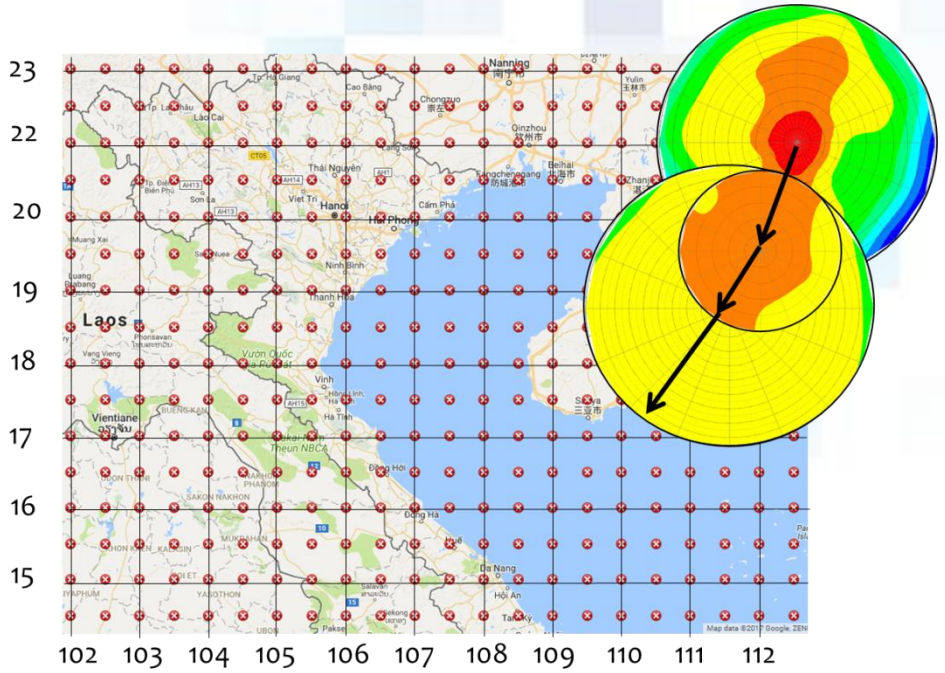

We may consider continuing the development depending on the conclusion of this meeting

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Limitations

- Scope of the assessment
  - No results of air concentration, ground concentration and lead time
  - Cannot account for geographical aspects
- Quality of the assessment
  - Continuous assessment
  - Accurate dose assessment

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Our Solution: Nuclear ACcident Consequence Assessment code (NACCA)

- TINT is in the process of development of a calculation code referring to the practice of Japan
- NACCA will be able to deliver results of:
  - Air concentration
  - Ground concentration
  - Lead time
- NACCA adapts sequential puff-trajectory model
- Calculation is divided into modules, thus is traceable
- NACCA cannot account for geographical aspects

Scope of the assessment

Continuous assessment

Accurate dose assessment

Geographical aspects

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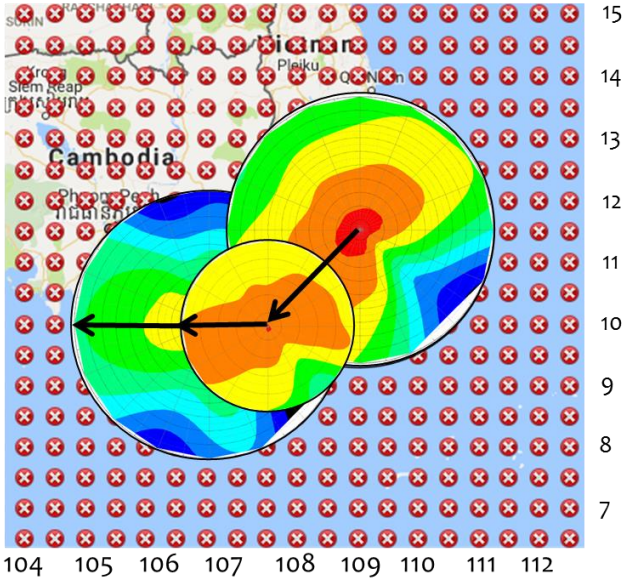
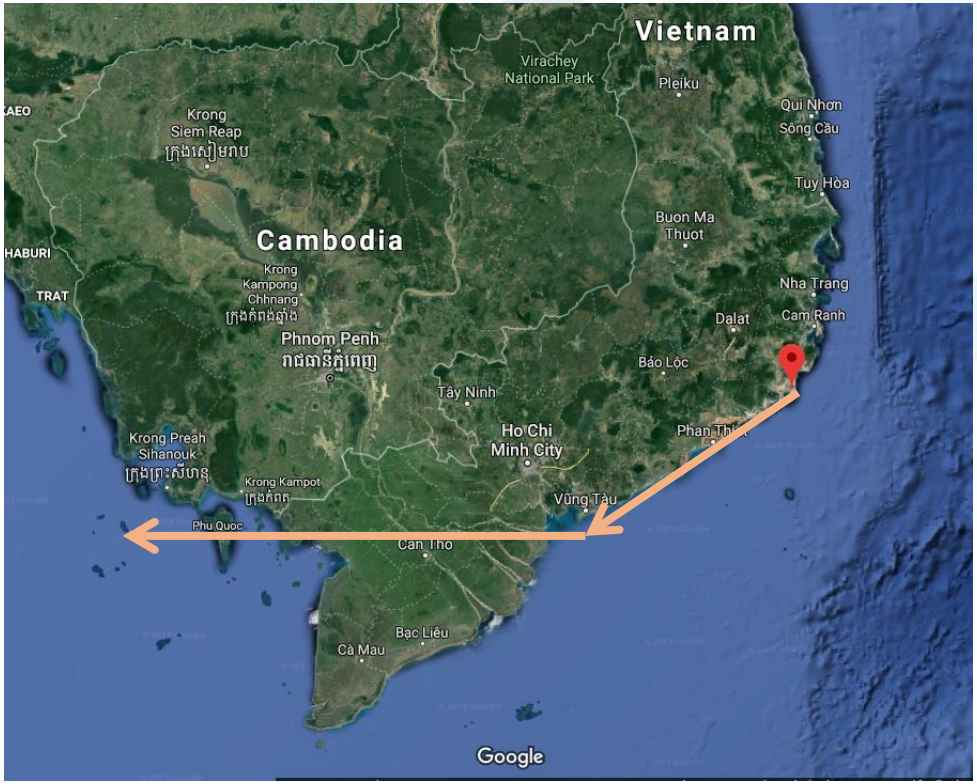
Our Solution(?): Qualitative Consideration of Geographical Aspects





Q. How essential is the geographical consideration in a long-range dispersion

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Proposals

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Assessment Conditions

- Location: Fangchenggang
- Core inventory: NUREG/ CR-6094
- Accident scenario: long-term SBO (24 hr release; Cs-137 = 1%, I-131 = 1%)
- Meteorological data: NOAA 2-D data of wind speed, wind direction, rainfall and weather stability class
  - Case I: Probabilistic calculation
  - Case 2: Deterministic calculation (50^{th} and 95^{th} percentile)
- Exposure pathways
  - Acute: cloundshine, groundshine, inhalation
  - Chronic: groundshine, resuspension, ingestion
- Geographical consideration: -

Results to be Compared

- Radii for comparison
  - 5 km, 8 km (5 miles), 10 km, 16 km (10 miles), 20 km, 30 km, 50 km, 80 km (50 miles), 100 km, 200 km, 300 km and 500 km
- Items to be compared
  - Air concentration (Bq/m^3)
  - Ground concentration (Bq/m^2)
  - TEDE (Sv)
  - Dispersion pattern
  - Lead time until the radioactive plume reaches the border of the neighboring countries (h)

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Project Implementation

- Conclusion of the assessment conditions and results to be compared – March 17
- File sharing on the system
  - Documents must be shared at least one week before the project meeting
- Project meeting
  - Once a month; third week (?)
- Discussion at the annual meeting
  - Once a year, one day per time
- Thailand volunteers to lead the project

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Thank you!

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