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Preliminary Report: Results of Computed Tracer Concentrations over Eastern China, South Korea, and Japan for 01 March to 30 May 2007 Daily Simulated Releases from Taiyuan, China

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Disclaimer

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Abstract:

In order to prepare for a proposed long range tracer experiment in China for the spring of 2008 time period, NARAC computed hypothetical PMCH concentrations over Eastern China, South Korea and Japan for simulated releases from Taiyuan, China. Normalized 1 kg of PMCH source strength releases were made twice a day, with wind input from global forecast weather model. We used 6-hour analysis fields valid at the start of each model run, resulting in four wind fields per day. The selected domain encompassed the region of interest over eastern Asia and the Western Pacific.

Screening runs were made for each day at 0000 and 1200 UTC from 01 April, 2007 through 29 May, 2007 for a total of 90 days and 180 cases. 24-hour average air concentrations were evaluated at 22 sample cities in the three regions of interest for each case. 15 sample cities were selected to help quantify modeling results for experiment objectives. Any case that resulted in model predicted air concentrations exceeding 2.0E-02 fL/L at a sample city in all three regions was then selected for a detailed model run with source times six hours before and after evaluated in addition to the case time. The detailed runs used the same wind fields and model domain, but 6-hour average air concentrations were generated and analyzed for the 15 sample cities.

Each of the 180 cases were ranked subjectively, based on whether or not the model prediction indicated the possibility that a release on that date and time might achieve the long range experiment objectives. Ranks used are High, Good, Low, Poor, and Bad. Of the 180 cases run, NARAC dispersion models predicted 6 instances of High possibility, 8 cases of Good, 32 of Low, 74 of Poor, and 60 cases of Bad probability. Detailed model runs were made for all 14 High or Good probability cases, a total of only 7.8% of all analyzed.

Based on the results of this study we have identified a few dates on which a release of a reasonable amount of PMCH tracer (on the order of 500 kg) might be detected in all three regions of interest. Weather patterns for the 15 cases which met experiment objectives should be studied to help identify future favorable times for the releases. Additionally, particularly bad weather patterns can also be evaluated as times for releases to be avoided.

Description of Screening Model Runs:

We chose to make two releases at 1200 and 0000 UTC (2000 and 0800 Local respectively) each day. A normalized source of 1 kg of PMCH gas was released for one hour each time from a 30m diameter sphere, 30 meters above ground.

24-hour averaged air concentrations were calculated for each release time over the next six days at 21 cities (Table 1). We used the preferred region for the proposed tracer study to select three cities in eastern China and seven cities in western Japan on western or central Honshu, Kyushu, or Shikoku Islands to for emphasis when analyzing the resulting pattern of 24-hour averaged air concentrations. All five cities were used in South Korea.

Table 1. Screening cities where 24-hour averaged air concentrations were evaluated for release time periods for subsequent detailed runs.

Name	Latitude / Longitude	Name	Latitude / Longitude
Beijing [a]	39 55N 116 25E	Kagoshima [b]	31 36N 120 33E
Qingdao [a]	36 06N 120 19E	Kanazawa [b]	36 34N 136 39E
Dalian [a]	38 53N 121 35E	Kitakyushu [b]	33 53N 130 50E
Shanghai	31 07N 121 22E	Kochi [b]	33 33N 133 33E
Nanjing	32 03N 118 47E	Oita [b]	33 14N 131 36E
		Osaka [b]	34 40N 135 30E
Seoul	37 35N 126 58E	Tokyo [b]	35 42N 139 46E
Pusan	35 06N 129 03E	Hachinohe	40 30N 141 29E
Kwangju	35 09N 126 54E	Kushiro	42 58N 144 23E
Cheju Do	33 20N 126 30E	Okinawa	26 20N 127 50E
Taejon	36 20N 127 26E	Sapporo	43 03N 141 21E

Notes: a: Three locations in eastern China emphasized for air-concentration screening.
b: Seven locations in western or central Japan emphasized for air-concentration screening.

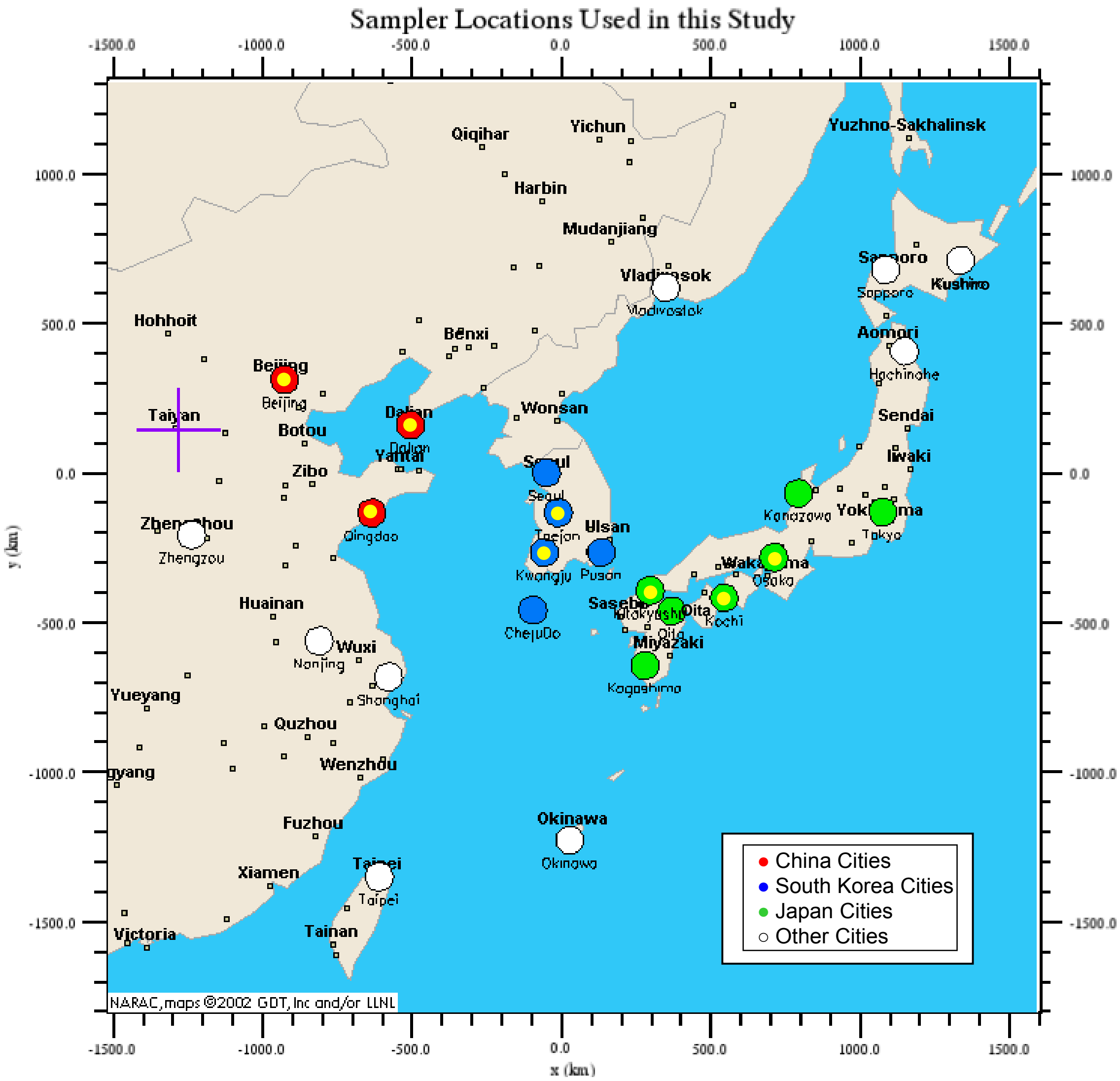

Figure 1. Map of cities used in this study to screen first for potential release dates with emphasis placed on the colored cities. For detailed analysis, time-history statistics were generated at some of the cities with yellow dots depending on the case. The proposed release location is marked with a '+'.

We used the Global Forecast System (GFS)[1] model with 0.5° resolution for wind input. Winds for each 6-hr model run analysis fields for 0000, 0600, 1200, and 1800 UTC provided input to the dispersion calculations each day. For the screening runs neutral boundary layer conditions (800 m boundary layer height and Monin-Obukhov length of 0.0 m) were used for all time periods during the day due to the large domain scale.

Release dates with the highest 24-hour average air concentrations over the three countries were then selected for more detailed model runs. Table 2 shows the dates in March 2007 with the potentially detectable air concentrations identified by the screening runs.

Table 2. 24-hour average air concentrations from the screening runs in March 2007 where the weather pattern produced potentially detectable levels of PMCH tracer over all three countries of interest.

Date and Source Time (UTC)	All China (fL/L)	China three preferred cities (fL/L)	All Japan (fL/L)	Japan seven preferred cities (fL/L)	South Korea (fL/L)	Rank
10 Mar 1200	7.80E-02	1.46E-01	1.19E-02	1.36E-02	8.18E-02	High
19 Mar 1200	7.03E-03	7.03E-03	7.65E-03	9.38E-03	2.14E-03	Good
24 Mar 0000	2.80E-03	4.69E-03	8.42E-03	1.17E-02	7.82E-03	Good
24 Mar 1200	1.04E-02	1.90E-02	8.93E-03	1.14E-02	1.25E-02	Good

See Appendix A for a summary of the 24-hour average air concentration results for all days.

Description of Detailed Model Runs:

In order to fine-tune the time of release that produced the highest 24-hour average air concentrations, release times six hours before and after were also analyzed. For example, for the March 10, 2007 Case, releases of PMCH for were made for 0600 (1400 LT), 1200, and 1800 (2400 LT) UTC.

The same wind inputs and turbulence parameters were used for the detailed runs as for the screening runs. Six-hour average air concentrations were calculated for the following cities representative of the areas of interest in each country:

1. Dalian and Qingdao or Beijing
2. Taejon and Kwangju
3. Kitakyushu, Kochi, and Osaka

Time history analysis of the subsequent concentrations were analyzed for the best possible release time and the necessary release amount to produce a detectable PMCH level over the eastern most (furthest away cities in Japan) that also produced detectable levels in South Korea and China.

Example of Model Run process and NARAC Model Results for 1200 UTC 10 March, 2007 Source Case

This case produced the highest concentration of all the other March release cases over the three countries of interest. The highest concentrations for this case occurred with the 0600 UTC source for all seven cities except Kitakyushu, Japan where only a slightly higher value was calculated for the 1200 UTC source.

Winds at the release are approximately a 317° (northwest) wind at 2.8 m/s at the surface near the release based on the GFS model input (Figure 2). This figure shows example ADAPT[2] model interpolated gridded winds over the model domain near the surface. Length of vectors show relative wind speed, as well as the direction.

Model interpolated wind fields for 1000m and 5000m above ground level are also indicated below (Figure 2b and 2c). They show examples of wind conditions above the PBL (height of 800m) used for all cases.

For this particular case there appears to be a strong west to northwest flow condition above the surface. Strong northwest flow from Mongolia flattens out into a trough over the Korean Peninsula at 1000m, with a strong zonal westerly jet indicated at 5000 m AGL.

This study will not attempt to characterize weather patterns that produced model computed favorable air concentrations for all the detailed cases run. This study will identify potentially favorable dates and leave the analysis to local experts in Japan, South Korea, or China.

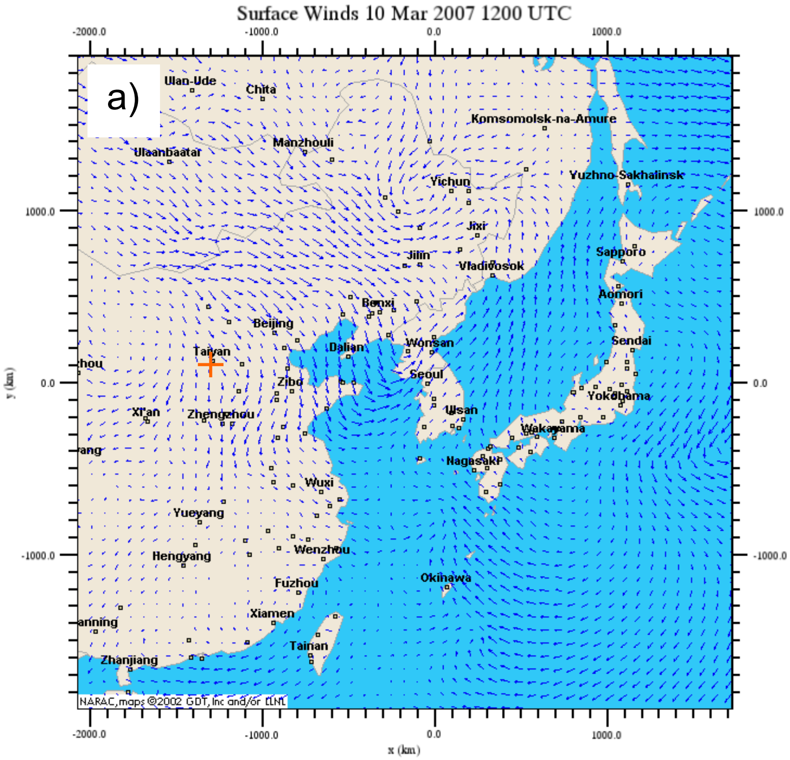

Figure 2a. Surface winds for 1200 UTC 10 March, 2007 over the model domain used for this study. Release location indicated with the red '+'.

Examples of NARAC LODI[2] Model particles representing the three detailed release times are displayed in Figure 3. Particle position figures show the instantaneous location of all particles across the domain at all altitudes (satellite-eye view). Particles have been color-coded associated with their release time. Each figure is valid at 0000 UTC beginning the day after the time of the release case.

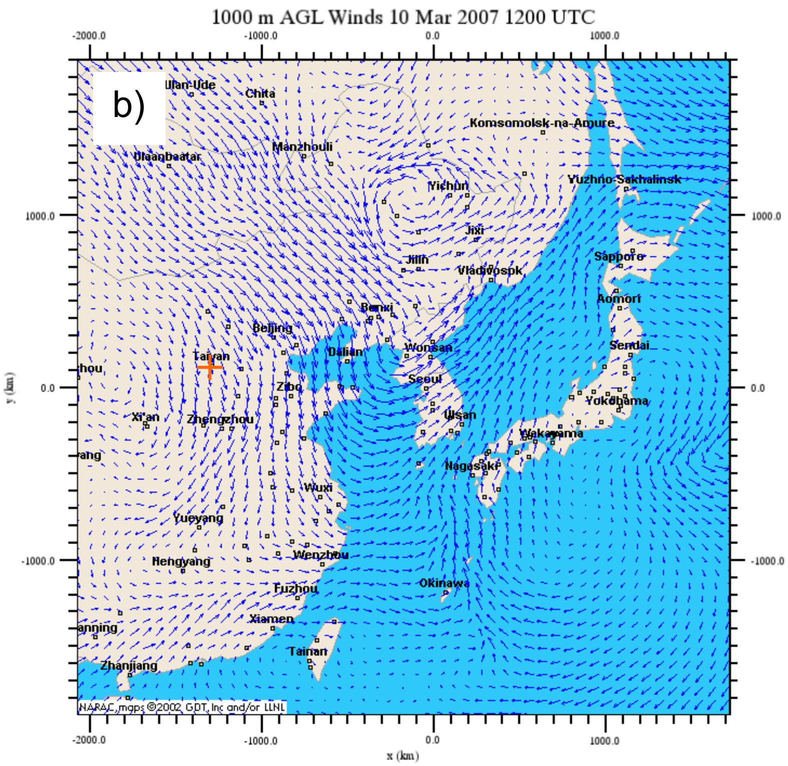

Figure 2b. Example of ADAPT winds at 1000 m AGL winds for 1200 UTC 10 March, 2007 interpolated from the GFS model.

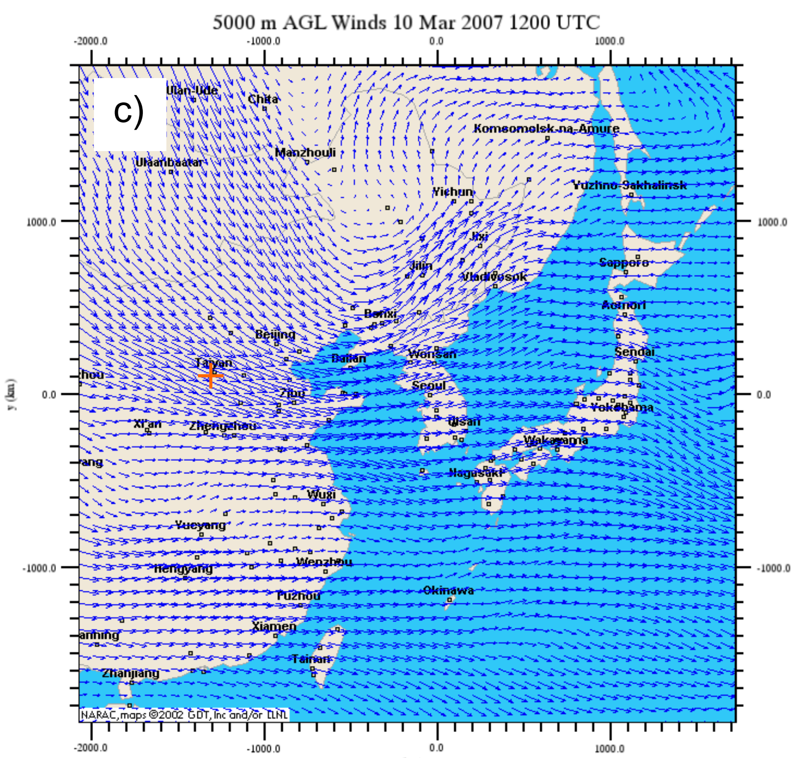

Figure 2c. Example of 5000 m AGL winds for 1200 UTC 10 March, 2007.

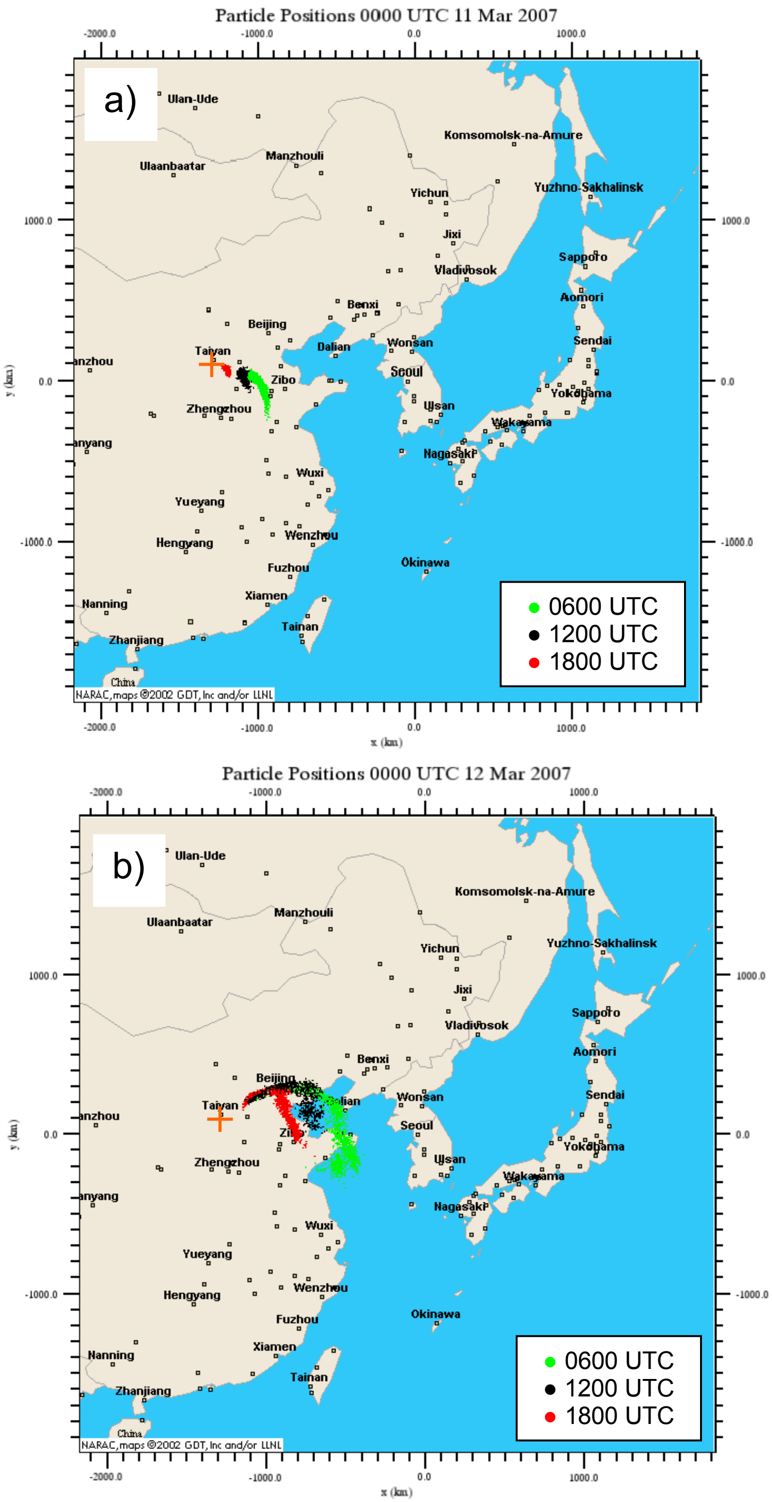

Figure 3a & b. Example particle positions for 10 March source times. a) 0000 UTC 11 March, 2007, b) 0000 UTC 12 March 2007. Particles for release time of 0600 UTC on 10 March indicated in green, 1200 UTC in black and 1800 UTC in red.

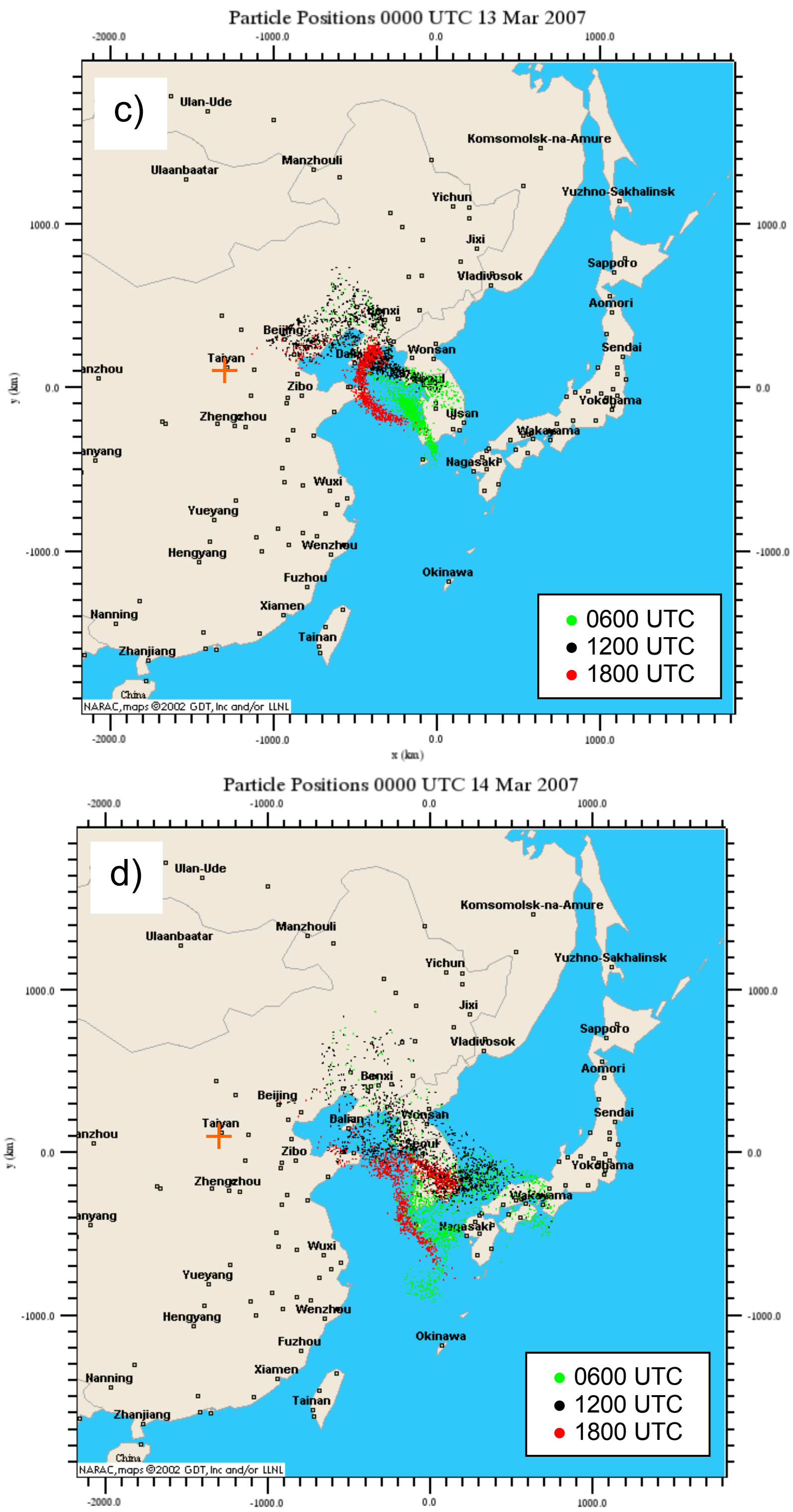

Figure 3c & d. Example particle positions for 10 March source times. c) 0000 UTC 13 March, 2007, d) 0000 UTC 14 March 2007. Particles for release time of 0600 UTC on 10 March indicated in green, 1200 UTC in black and 1800 UTC in red.

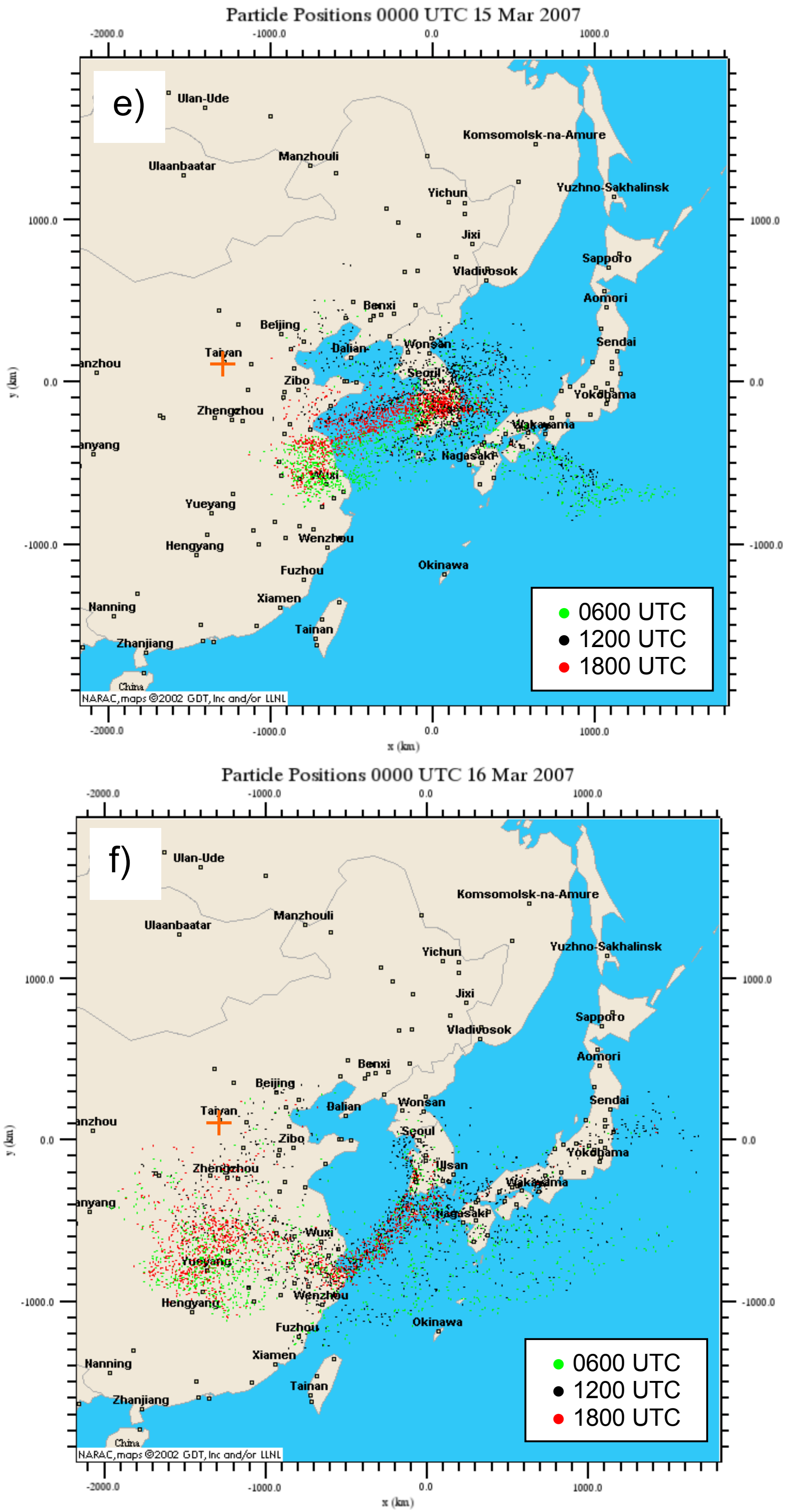

Figure 3e & f. Example particle positions for 10 March source times. e) 0000 UTC 15 March, 2007, f) 0000 UTC 16 March 2007. Particles for release time of 0600 UTC on 10 March indicated in green, 1200 UTC in black and 1800 UTC in red.

This series of example figures show the evolution of all three plumes as they spread out over the course of the six-day run. The plumes generally move across all three countries of interest: eastern China, South Korea, and Japan. Note that the structure of the plumes as represented by the particles spread out and move at different speeds as a result of vertical and horizontal variations in wind speed and direction. As a result, the particles can spread out over a large area by the end of the run, including areas outside of the experiment preferred modeling region.

This paper will not characterize the plume evolution for each individual detailed case study. It is hoped the that additional weather analysis of favorable cases identified here will help understand how the modeled plume produced predicted air concentration values that are potentially detectable in all three countries of interest.

Modeled concentrations will be presented for all cases run in this study using time-history charts of predicted 6-hour average air concentrations at seven of the cities of interest indicated in Figure 1 (noted by interior dots).

Time-history analysis for the March 10 case (Figure 4a-g) show that the concentrations are highest in Dalian (order of 0.5 fL/L) for the 0600 UTC release time but relatively high in Qingdao for all three release times. Two distinct peaks in air concentrations are evident at both cities for the earliest two release times. The first occurs with the initial plume passage within 1-2 days, but then a second peak arrives as the material spreads slowly eastward and northward in days 4-6.

Charts for Korea (Figure 4c & d) show a fairly broad peak, consistent with the model predictions for the plume to linger over South Korea for days 4-6. Highest 6-hour average air concentration occurs for the 0600 UTC time.

Charts for Japan show the highest concentrations by far for the 0600 and 1200 UTC times, and nearly identical for both. Based on this data it appears that a high-possibility weather pattern to release material is the pattern that occurred on 10 March, 2007 at 0600 and 1200 UTC.

Based upon the maximum model-derived air concentrations calculated for 0600 and 1200 UTC for a 1-hour release of 1-kg of PMCH, Table 3 below summarizes the amount of PMCH required to be released over 1 hour to produce air concentrations greater than the limit of detection of 12 fL/L[4]. For example, the table shows that to get a detectable level of PMCH in Osaka, 862 kg needs to be released.

Table 4 shows the model-predicted air concentration measurement at all seven cities given the source amount released of 100, 500, or 1000 kg of PMCH. A source of 1000 kg would be needed for all seven representative cities to have above-background measurements. But a source of 500 kg will produce model-derived detectable levels at all cities except Osaka (the furthest east).

Table 5 shows the arrival times in hours from the start of the release for the peak 6-hour average air concentration and the first greater than 2.0 fL/L.

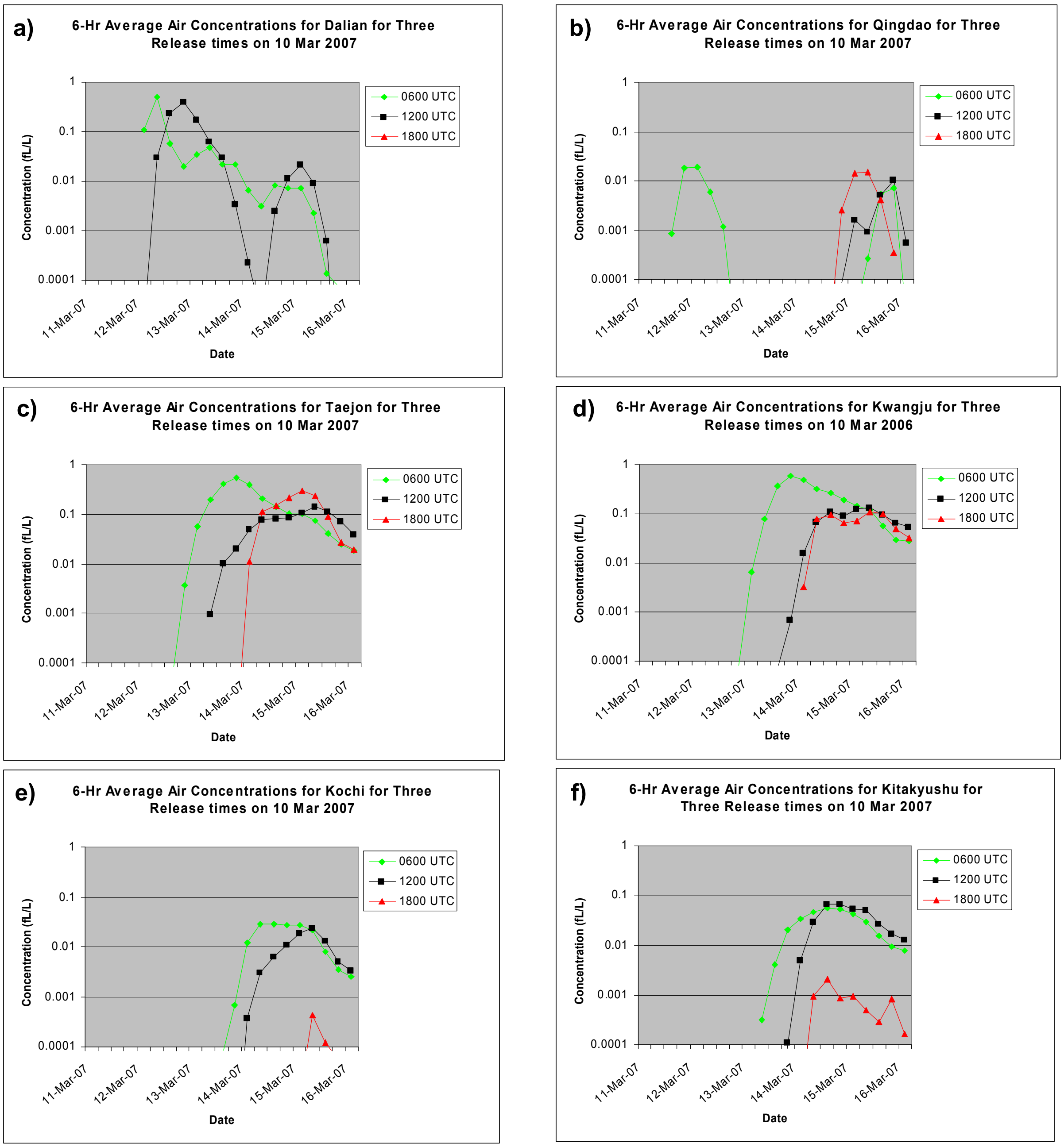

Figure 4a-f. Time-history of 6-hour average air concentrations for releases at 0600, 1200, and 1800 UTC on 10 March, 2007. Color of the concentrations are the same as the colors on the particles in Figure 3 for the same times.

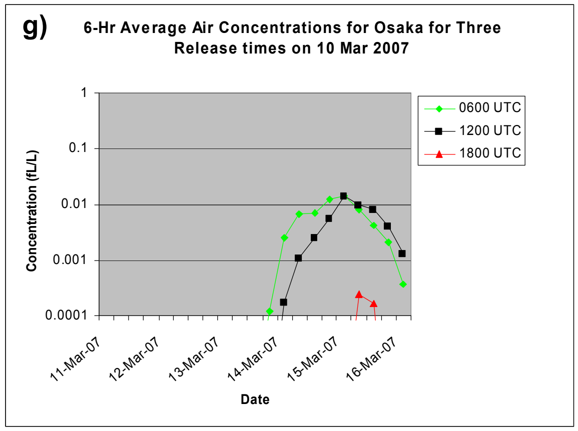

Figure 4g. Time-history of 6-hour average air concentrations for releases at 0600, 1200, and 1800 UTC on 10 March, 2007. Color of the concentrations are the same as the colors on the particles in Figure 3 for the same times.

Table 3. Maximum concentration computed at any time for sample cities as well as the computed source strength required to obtain the computed value assuming a detection level of 12 fL/L PMCH, for both 0600 and 1200 UTC sources on 10 March 2007.

City	Max 6-Hr Ave Air Conc. for 0600 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)	Max 6-Hr Ave Air Conc. for 1200 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	5.00E-01	24	3.91E-01	31
Qingdao	1.91E-02	629	1.03E-02	1170
Taejon	5.51E-01	22	1.42E-01	85
Kwangju	5.85E-01	21	1.33E-01	90
Kitakyushu	5.63E-02	213	6.81E-02	176
Kochi	2.88E-02	417	2.40E-02	499
Osaka	1.39E-02	862	1.39E-02	862

Table 4. Computed measurements at each sample city given the source strength indicated, for both 0600 and 1200 UTC sources on 10 March 2007.

	Measurement value computed for given source strength for 0600 UTC source (Values in fL/L)			Measurement value obtained for given source strength for 1200 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg	1000 Kg	500 kg	100 kg
Dalian	500	250	50	391	196	39
Qingdao	19	10*	2*	10*	5*	1*
Taejon	551	276	28	142	71	14
Kwangju	585	293	59	133	67	13
Kitakyushu	56	28	6*	68	34	7*
Kochi	29	14	3*	24	12	2*
Osaka	14	7*	1*	14	7*	1*

*Value is below threshold of approximately 12 fL/L of PMCH

Table 5. Model computed arrival times of both peak 6-hour average and the first greater than 2.0 fL/L air concentration.

	0600 UTC source Arrival time (hrs)		1200 UTC source Arrival time (hrs)	
Concentration:	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak
Dalian	48	54	48	60
Qingdao	-	48	-	147
Taejon	72	90	84	120
Kwangju	78	90	96	126
Kitakyushu	90	102	96	102
Kochi	102	102	120	120
Osaka	-	120	-	114

NARAC Model Results for 19 March, 2007 1200 UTC Case

Model computed concentrations for 19 March are not as high as predicted values for the 10 March source. However, values are still estimated to reach detectable levels in all sample cities chosen to represent the three regions within the experiment goal.

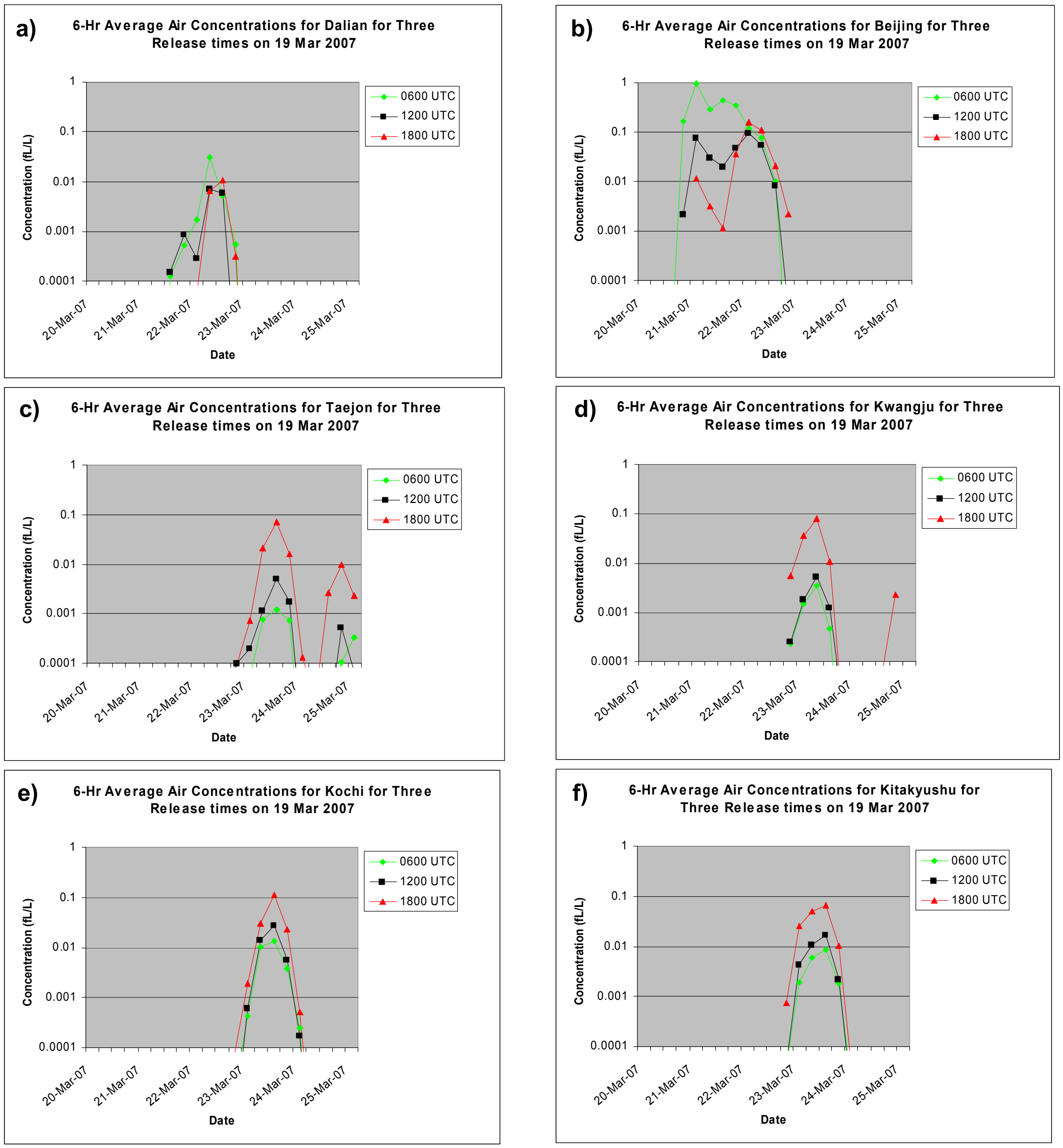

Figure 5a-f. Time-history of 6-hour average air concentrations for releases at 0600, 1200, and 1800 UTC on 19 March, 2007.

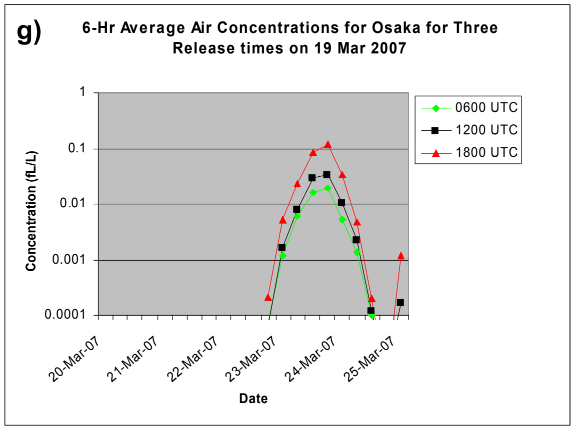

Figure 5g. Time-history of 6-hour average air concentrations for releases at 0600, 1200, and 1800 UTC on 19 March, 2007.

The sample cities for eastern China were switched to Dalian and Beijing for this case (Figure 5a & b). Qingdao did not have any predicted concentrations greater than zero. The highest concentration in Beijing is almost 1.0 fL/L for the 0600 UTC release time, but due to the greater concentrations achieved for 1800 UTC release time in South Korea and Japan, the 1800 UTC time will only be analyzed.

Charts for Korea (Figure 5c & d) show a sharper peak compared to the 10 March case, with the highest 6-hr average for the 1800 UTC release time. The model predicted the highest values close to 0.1 fL/L for both Kwangju and Taejon.

The 1800 UTC release time also resulted in the highest 6-hr average air concentrations for all three representative cities in Japan as well. Values in general are higher for all three cities than for the 10 March release scenario.

Table 6 summarizes the amount of PMCH required to be released over 1 hour to produce air concentrations greater than the limit of detection of 12 fL/L for the 1800 UTC release time. Table 6 show the model-predicted air concentration measurement at all seven cities given the source amount released of 100, 500, or 1000 kg of PMCH.

The plume appears to have taken a more northerly trajectory across the region of interest (not shown) compared to the 10 March Case. Consequently, relatively higher concentrations are predicted to occur over northeastern China, northern South Korea, and Central Honshu. Note that higher concentrations were predicted over Honshu than over southeastern South Korea.

Table 8 shows the arrival times in hours from the start of the release for the peak 6-hour average air concentration and the first greater than 2.0 fL/L.

Table 6. Maximum concentration computed at any time for sample cities as well as the computed source strength required to obtain the computed value assuming a detection level of 12 fL/L PMCH, for the 1800 UTC source on 19 March 2007.

City	Max 6-Hr Ave Air Conc. for 1800 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	1.07E-02	1120
Beijing	1.58E-01	76
Taejon	7.16E-02	168
Kwangju	8.09E-02	148
Kitakyushu	6.63E-02	181
Kochi	1.13E-01	106
Osaka	1.18E-01	102

Table 7. Computed measurements at each sample city given the source strength indicated, for 1800 UTC source on 19 March 2007.

	Measurement value computed for given source strength for 1800 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg
Dalian	11	5*	1*
Beijing	158	79	16
Taejon	72	36	7
Kwangju	81	40	8
Kitakyushu	66	33	7*
Kochi	113	57	11*
Osaka	118	59	12

*Value is below threshold of approximately 12 fL/L of PMCH

Table 8. Model computed arrival times of both peak 6-hour average and the first greater than 2.0 fL/L air concentration.

	1800 UTC source Arrival time (hrs)	
Concentration:	> 2.0 fL/L	Peak
Beijing	54	66
Dalian	-	72
Taejon	90	96
Kwangju	84	90
Kitakyushu	84	96
Kochi	90	96
Osaka	90	102

NARAC Model Results for 24 March, 2007, 0000 and1200 UTC Cases

Two potential release cases occurred consecutively on 24 March- 0000 and 1200 UTC. Therefore, more detailed analysis of release times were made for five consecutive times from 1800 UTC 23 March to 18 UTC 24 March 2007 to evaluate results for releases 6 hours before and after each screening run release time.

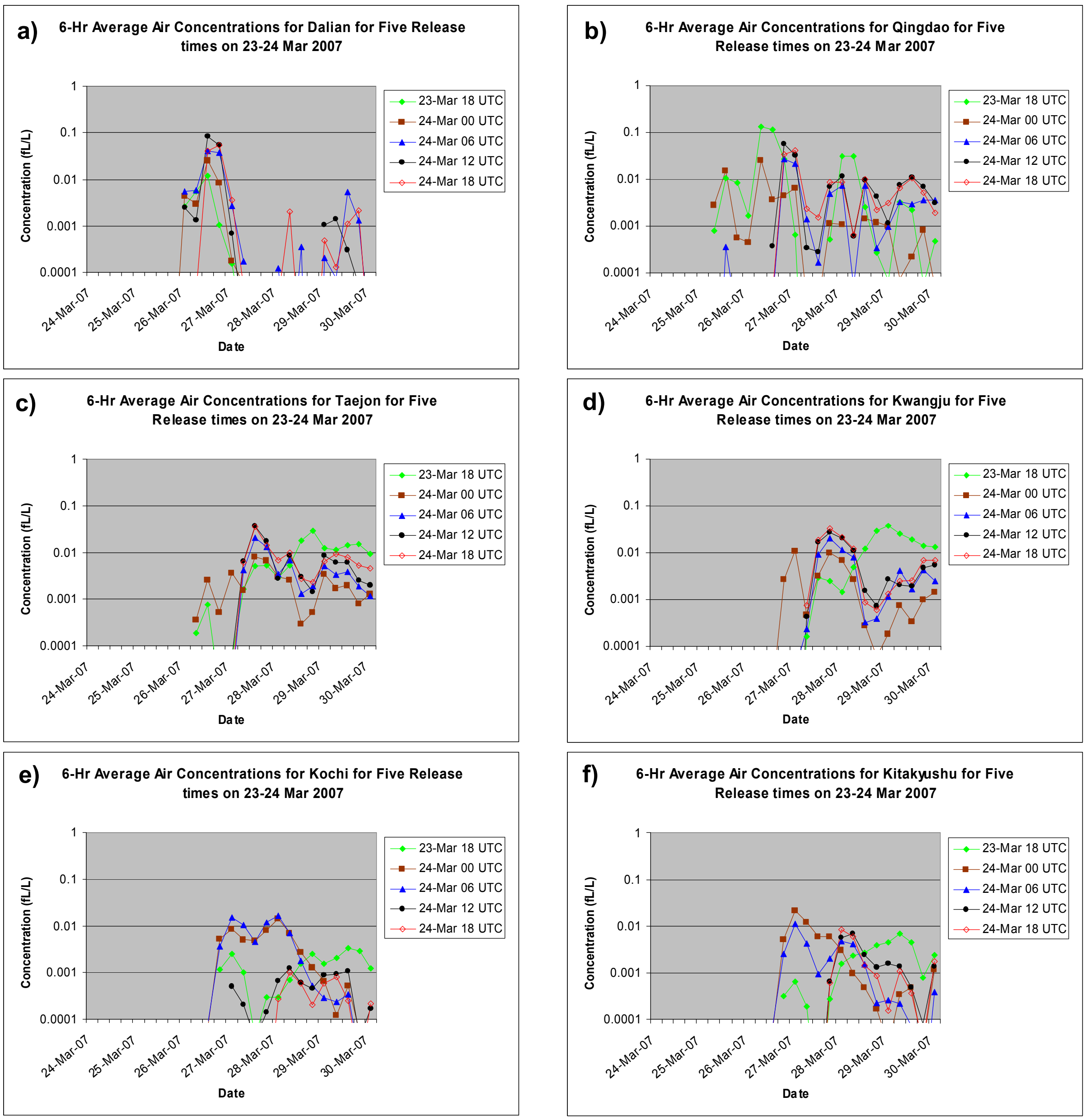

Figure 6a-f. Time-history of 6-hour average air concentrations at six sample cities for releases at 1800 UTC 23 March, and 24 March at 0000, 0600, 1200, and 1800 UTC.

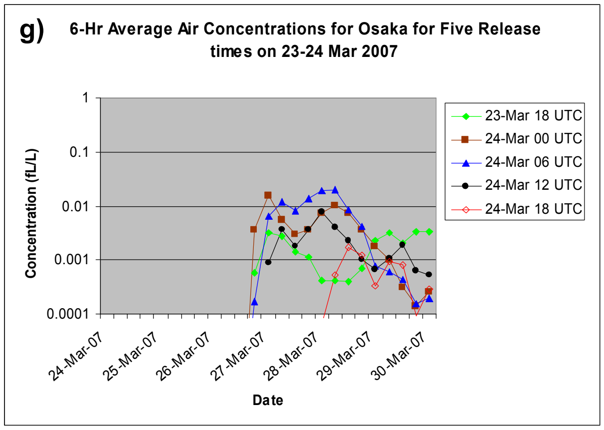

Figure 6g. Time-history of 6-hour average air concentrations at Osaka for releases at 1800 UTC 23 March, and 24 March at 0000, 0600, 1200, and 1800 UTC.

Analysis of the model results show two release times that produced the highest detailed model run air concentrations over all three regions of interest: 0000 and 0600 UTC on 24 March, 2007. These times were selected because the highest concentrations obtained in South Korea or Japan for the five release times occurred then. The highest concentrations computed in both countries are about the same, around 0.01 fL/L (Figure 6a-g).

Higher concentrations were calculated for other release times in China, particularly for the 1200 UTC 24 March release time (Figure 6a & b) with computed concentrations about 0.1 fL/L at both Qingdao and Dalian. Concentrations in Korea are about the same as in China (Figure 6c & d), but concentrations computed in Japan for this release time are less than 0.01 fL/L (Figure 6e-f). Computed concentrations below 0.01 fL/L require more than 1000 kg released from Taiyuan to produce detectable levels in Japan. Consequently, this time was not considered.

Table 9 indicates that several hundreds of kilograms of PMCH need to be released to get detectable levels over all three regions of interest. The lowest amount is 323 kg to get a detectable level outside of China for the 1200 UTC release time (in Taejon), to as much as 1470 kg for the same city for a 0600 UTC release time.

Table 10 shows that even with a 1000 kg release of PMCH model computed air concentrations do not exceed detectable levels for all sample cities. For the 0600 UTC release time the model predicts only threshold values in South Korea. Slightly better results are attained for the 1200 UTC source for which the model indicates detectable levels for all sample cities except for a threshold value in Kitakyushu, Japan.

Table 11 shows the arrival times in hours from the start of the release for the peak 6-hour average air concentration and the first greater than 2.0 fL/L.

Table 9. Maximum concentration computed at any time for sample cities as well as the computed source strength required to get the computed value assuming a detection level of 12 fL/L PMCH, for the 0000 and 0600 UTC sources on 24 March 2007.

City	Max 6-Hr Ave Air Conc. for 0000 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)	Max 6-Hr Ave Air Conc. for 0600 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	2.55E-02	471	4.11E-02	292
Qingdao	2.60E-02	462	2.67E-02	450
Taejon	8.16E-03	1470	2.07E-02	323
Kwangju	1.07E-02	1120	1.99E-02	603
Kitakyushu	2.10E-02	572	1.12E-02	1070
Kochi	1.44E-02	835	1.61E-02	747
Osaka	1.58E-02	762	1.99E-02	604

Table 10. Computed measurements at each sample city given the source strength indicated, for 0000 and 0600 UTC sources on 24 March 2007.

	Measurement value computed for given source strength for 0000 UTC source (Values in fL/L)			Measurement value obtained for given source strength for 0600 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg	1000 Kg	500 kg	100 kg
Dalian	25	13	3*	41	21	4*
Qingdao	26	13	3*	27	14	3*
Taejon	8*	4*	1*	21	11*	2*
Kwangju	11*	6*	1*	20	10*	2*
Kitakyushu	21	11*	2*	11*	6*	1*
Kochi	14	7*	1*	16	8*	2*
Osaka	16	8*	2*	20	10*	2*

*Value is below threshold of approximately 12 fL/L of PMCH

Table 11. Model computed arrival times of both peak 6-hour average and the first greater than 2.0 fL/L air concentration.

	0000 UTC source Arrival time (hrs)		0600 UTC source Arrival time (hrs)	
Concentration:	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak
Dalian	90	90	84	84
Qingdao	84	84	90	90
Taejon	-	114	108	108
Kwangju	-	102	114	114
Kitakyushu	102	102	-	96
Kochi	-	126	-	120
Osaka	-	102	126	126

April 2007 Results

Only one three-day period during the month of April, and the five consecutive releases beginning on 1200 UTC on 22 April 2007 through 1200 UTC on 24 April all showed very good model predicted potential to produce detectable levels in all three countries of interest.

Table 12. 24-hour average air concentrations from the screening runs in April 2007 where the weather pattern produced potentially detectable levels of PMCH tracer over all three countries of interest.

Date and Source Time (UTC)	All China (fL/L)	China three preferred cities (fL/L)	All Japan (fL/L)	Japan seven preferred cities (fL/L)	South Korea (fL/L)	Rank
22 Apr 1200	9.43E-02	2.46E-03	1.72E-02	1.96E-02	3.30E-02	Good
23 Apr 0000	5.29E-02	8.55E-02	6.16E-02	9.44E-02	1.00E-01	High
23 Apr 1200	9.54E-02	2.53E-01	8.46E-02	9.63E-02	8.13E-02	High
24 Apr 0000	5.17E-02	1.04E-01	4.53E-02	5.78E-02	7.48E-02	High
24 Apr 1200	2.39E-02	4.57E-02	3.06E-02	3.92E-02	5.13E-02	Good

See Appendix A for a summary of the 24-hour average air concentration results for all days in April.

Consequently, detailed case studies were made for 0600, 1200, and 1800 UTC on 22 April and for 0000, 0600, 1200, and 1800 UTC on 23 and 24 April.

NARAC Model Results for 22 April, 2007, 1200 UTC Case

This case is the first of five consecutive release times that model calculations project could meet the screening criteria. For this case detailed model runs were made for 0600, 1200, and 1800 UTC.

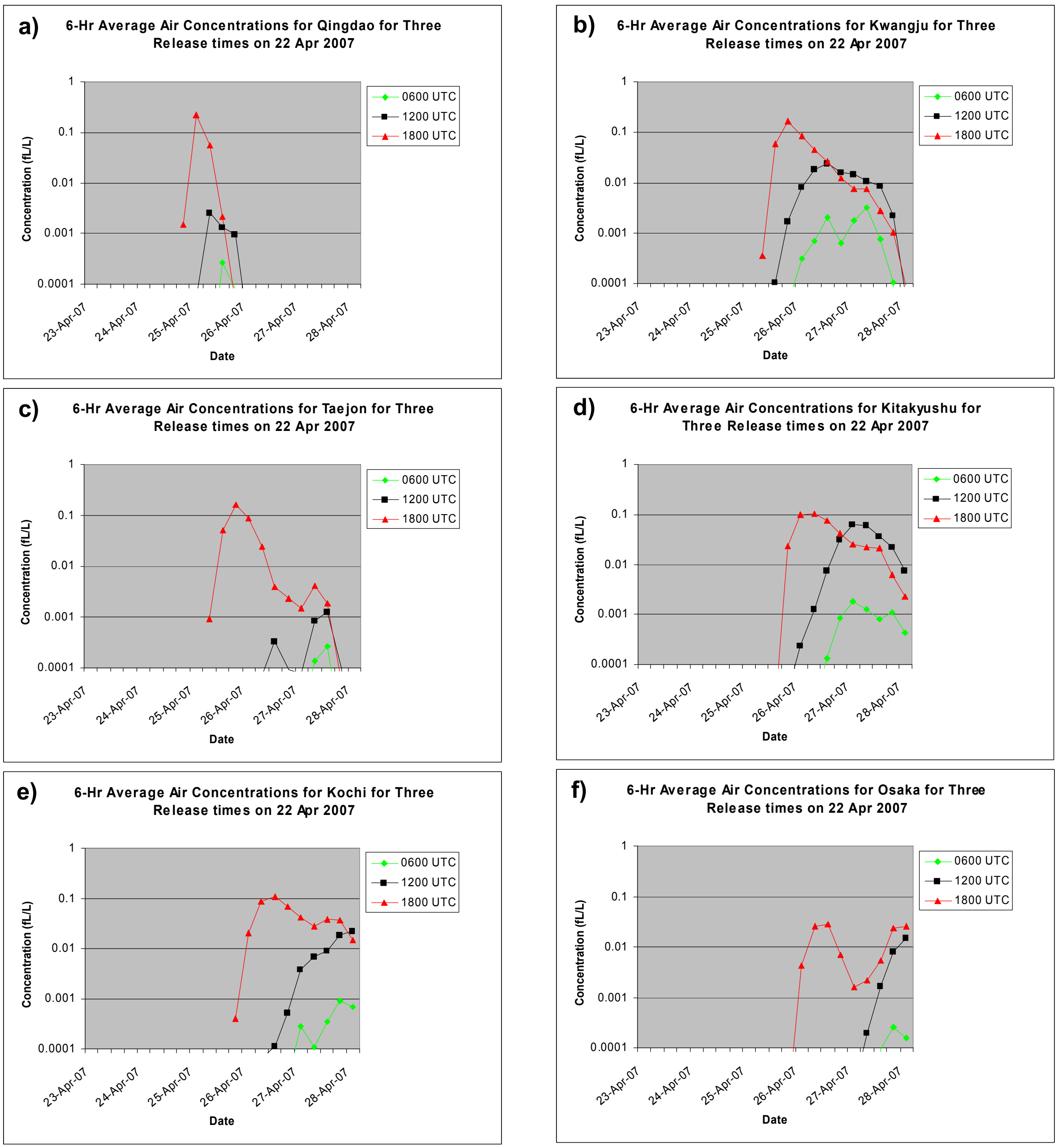

Figure 7a-f. Time-history of 6-hour average air concentrations at six sample cities for releases at 0600, 1200, and 1800 UTC on 22 April, 2007.

Analysis of the time-history chart for Qingdao (Fix 7a) shows a single sharp peak due to a quick passage of the plume. No data was obtained for either Beijing or Dalian, but analysis of the particles over time indicates that the majority of the plume passed almost due west of Taiyuan over the Shantung Peninsula (Figure 8). The figure appears to show particles over Dalian at this time, but these are particles above the ground caught up in a strong west to east jet (note some particles already over Japan). The portion of the plume at the surface is both south and east of Taiyuan and moving westward. The lack of data to support this case to be favorable over China is limited by the sample cities I selected. Qualitative evidence shows that many other cities in Eastern China would likely receive detectable levels of PMCH for this case.

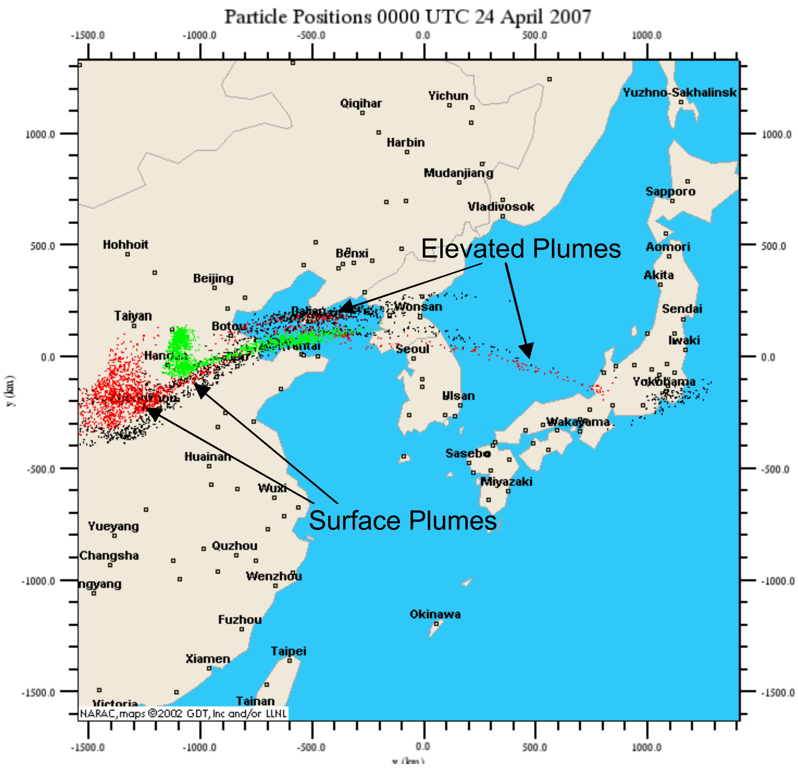

Figure 8. Particle positions for 0000 UTC 24 April, 2007 for the 22 April 2007 Case. Particles for release time of 0600 UTC on 22 April indicated in green, 1200 UTC in black and 1800 UTC in red.

Time history data for Korea (Fig 7c & d) show high computer calculated air concentrations, particularly for the southern-most city of Kwangju. Also the data shows a secondary peak passing Taejon on 28 April.

Model computed concentrations over Japan are very high (Fig 7e-f). Values exceed 1.0E-01 fL/L at Kochi and Kitakyushu.

Table 13 shows the computed source strength needed to reach a detectable level for the highest concentration calculated at a sample city. Note that a source of a little over 100 kg based on this model projection would be detected in Western Japan.

Table 13. Maximum concentration computed at any time for sample cities as well as the computed source strength required to get the computed value assuming a detection level of 12 fL/L PMCH, for the 1200 and 1800 UTC sources on 22 April 2007.

City	Max 6-Hr Ave Air Conc. for 1200 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)	Max 6-Hr Ave Air Conc. for 1800 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	-	-	-	-
Qingdao	2.58E-03	4660	2.21E-01	54
Taejon	1.22E-03	9800	1.63E-01	74
Kwangju	2.44E-02	493	1.62E-01	74
Kitakyushu	6.15E-02	195	1.04E-01	116
Kochi	2.28E-02	527	1.08E-01	111
Osaka	1.49E-02	807	2.76E-02	434

Table 14. Computed measurements at each sample city given the source strength indicated, for 1200 and 1800 UTC sources on 22 April 2007.

	Measurement value computed for given source strength for 1200 UTC source (Values in fL/L)			Measurement value obtained for given source strength for 1800 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg	1000 Kg	500 kg	100 kg
Dalian	-	-	-	-	-	-
Qingdao	3	1	>1	221	111	22
Taejon	1	>1	>1	163	82	16
Kwangju	24	12	2	162	81	16
Kitakyushu	62	31	6	104	52	10
Kochi	23	12	2	108	54	10
Osaka	15	8	2	28	14	3

*Value is below threshold of approximately 12 fL/L of PMCH

Table 15. Model computed arrival times of both peak 6-hour average and the first greater than 2.0 fL/L air concentration.

	1200 UTC source Arrival time (hrs)		1800 UTC source Arrival time (hrs)	
Concentration:	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak
Dalian	-	-	-	-
Qingdao	-	72	60	60
Taejon	-	126	72	78
Kwangju	102	102	72	78
Kitakyushu	108	114	78	90
Kochi	138	138	84	96
Osaka	-	138	90	96

Table 14 shows the computed measurements for the sample cities for three source strengths. A source strength of 500 kg might produce detectable levels in all three regions of interest, as far east as Osaka, Japan.

Table 15 shows the arrival times in hours from the start of the release for the peak 6-hour average air concentration and the first greater than 2.0 fL/L.

<u>NARAC Model Results for 23 April, 2007, 0000 & 1200 UTC Cases</u>

These cases are the second and third of five consecutive release times that model calculations project could meet the screening criteria. Model runs were made for 0000, 0600, 1200, and 1800 UTC for this detailed case.

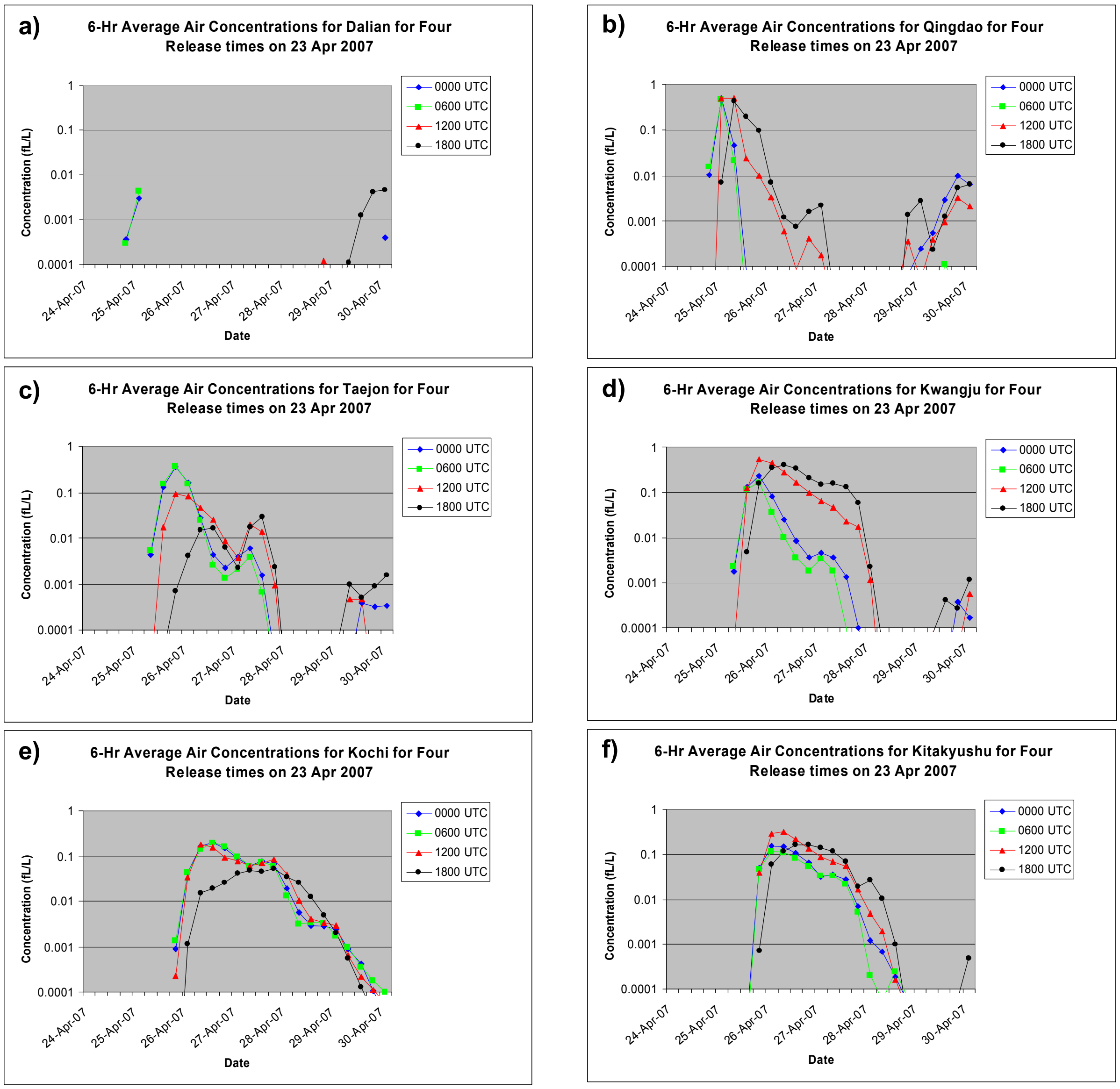

Figure 9a-f. Time-history of 6-hour average air concentrations at six sample cities for releases at 0000, 0600, 1200, and 1800 UTC on 23 April, 2007.

Time-history data for the Chinese city of Qingdao (Fig 9b) shows high levels of model-predicted air concentrations for all four release times, particularly on 25 April. Concentrations drop off rapidly after 25 April, below potential detectable limits for reasonable release amounts. A secondary peak on the edge of delectability arrives on 29 April. Data is not as good for Dalian (Fig 9a) due to the surface plume passing north of the city (not shown), but large areas of eastern China would experience detectable levels based on the data at Qingdao.

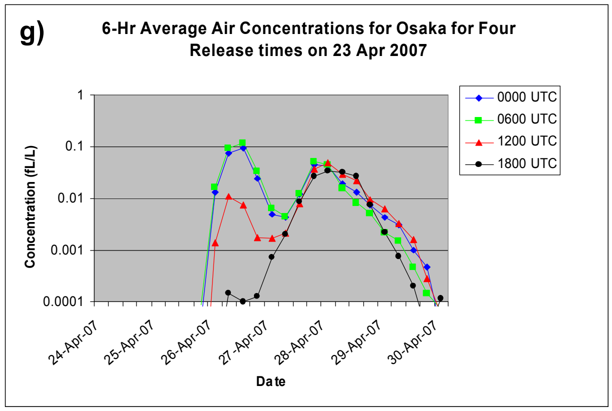

Figure 9g. Time-history of 6-hour average air concentrations at Osaka, Japan for releases at 0000, 0600, 1200, and 1800 UTC on 23 April, 2007.

Time-history data for Kwangju and Taejon (Fig 9c & d) both show predicted model air concentrations above detection limits beginning after 1200 UTC on 25 April. The best data for these two cities appears to occur for the 0000, 0600, and 1200 UTC release times as Taejon shows model predicted concentrations above 0.01 fL/L, about the detection threshold for reasonable source strengths.

Time-history data in Japan indicates a significant arrival peak for all three cities (Fig 9e-g) on 26 April, particularly for 0000 and 0600 UTC source times. Results for Osaka show a significant secondary peak for all four release times on 29 April.

Table 16a. Maximum concentration computed at any time for sample cities as well as the computed source strength required to get the computed value assuming a detection level of 12 fL/L PMCH, for the 0000 and 0600 UTC sources on 23 April 2007.

City	Max 6-Hr Ave Air Conc. for 0000 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)	Max 6-Hr Ave Air Conc. for 0600 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	3.07E-03	3900	4.38E-03	2740
Qingdao	4.95E-01	24	4.75E-01	25
Taejon	3.55E-01	34	3.68E-01	33
Kwangju	2.36E-01	51	1.63E-01	74
Kitakyushu	1.57E-01	77	1.16E-01	103
Kochi	2.03E-01	59	1.96E-01	61
Osaka	9.69e-02	124	1.21E-01	99

Model results are shown for all four release times, 0000 and 0600 UTC in Table 16a and 1200 and 1800 UTC in Table 16b. Data indicates that a source of only slightly over 100 kg is needed to produce a 12 fL/L measurement at a sample city for either 0000 or 0600 release times on 23 April, except in Dalian. Slightly higher source strength is needed for

1200 UTC, and much more material is needed for an 1800 release time on 23 April based on the model calculations.

Table 16b. Maximum concentration computed at any time for sample cities as well as the computed source strength required to get the computed value assuming a detection level of 12 fL/L PMCH, for the 1200 and 1800 UTC sources on 23 April 2007.

City	Max 6-Hr Ave Air Conc. for 1200 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)	Max 6-Hr Ave Air Conc. for 1800 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	1.22E-04	98700	4.58E-03	2620
Qingdao	5.00E-01	24	4.35E-01	28
Taejon	9.79E-02	129	2.96E-02	405
Kwangju	5.37E-01	22	4.00E-01	30
Kitakyushu	3.12E-01	38	1.66E-01	72
Kochi	1.83E-01	66	5.17E-02	232
Osaka	4.91E-02	244	3.43E-02	350

Table 17a. Computed measurements at each sample city given the source strength indicated, for 0000 and 0600 UTC sources on 23 April 2007.

	Measurement value computed for given source strength for 0000 UTC source (Values in fL/L)			Measurement value obtained for given source strength for 0600 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg	1000 Kg	500 kg	100 kg
Dalian	3*	2*	>1*	4*	2*	>1*
Qingdao	495	248	50	475	238	48
Taejon	355	178	36	368	184	37
Kwangju	236	118	24	163	33	7*
Kitakyushu	157	79	16	116	58	12
Kochi	203	102	20	196	98	20
Osaka	97	48	10*	121	61	12

*Value is below threshold of approximately 12 fL/L of PMCH

Table 17a & b show the model computed measurements obtained for three source strengths from 1000 to 100 kg of PMCH for all four release times on 23 April. A source strength of 500 kg is predicted to easily exceed detection limits in all three regions of interest for 0000, 0600, and 1200 release times, but only just above threshold for Taejon and Osaka for the 1800 release time..

Table 18 shows the arrival times in hours from the start of the release for the peak 6-hour average air concentration and the first greater than 2.0 fL/L.

Table 17b. Computed measurements at each sample city given the source strength indicated, for 1200 and 1800 UTC sources on 23 April 2007.

	Measurement value computed for given source strength for 1200 UTC source (Values in fL/L)			Measurement value obtained for given source strength for 1800 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg	1000 Kg	500 kg	100 kg
Dalian	>1*	>1*`	>1*	5*	1*	>1*
Qingdao	500	250	50	435	218	44
Taejon	98	49	10*	30	15	3*
Kwangju	537	269	54	400	200	40
Kitakyushu	312	156	31	166	83	17
Kochi	183	92	18	52	26	5*
Osaka	49	25	5*	34	17	3*

*Value is below threshold of approximately 12 fL/L of PMCH

Table 18. Model computed arrival times of both peak 6-hour average and the first greater than 2.0 fL/L air concentration.

	0000 UTC source Arrival time (hrs)		0600 UTC source Arrival time (hrs)		1200 UTC source Arrival time (hrs)		1800 UTC source Arrival time (hrs)	
Concentration:	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak
Dalian	-	54	-	48	-	132	-	156
Qingdao	48	54	42	48	42	42	42	42
Taejon	66	72	60	66	60	60	96	96
Kwangju	66	72	60	66	54	60	54	66
Kitakyushu	72	78	66	72	60	72	60	72
Kochi	78	90	72	84	66	72	78	102
Osaka	84	90	78	84	108	114	102	108

<u>NARAC Model Results for 24 April, 2007, 0000 & 1200 UTC Cases</u>

These cases are the fourth and fifth of five consecutive release times that model calculations project could meet the screening criteria. Model runs were also made for 0000, 0600, 1200, and 1800 UTC for this detailed case.

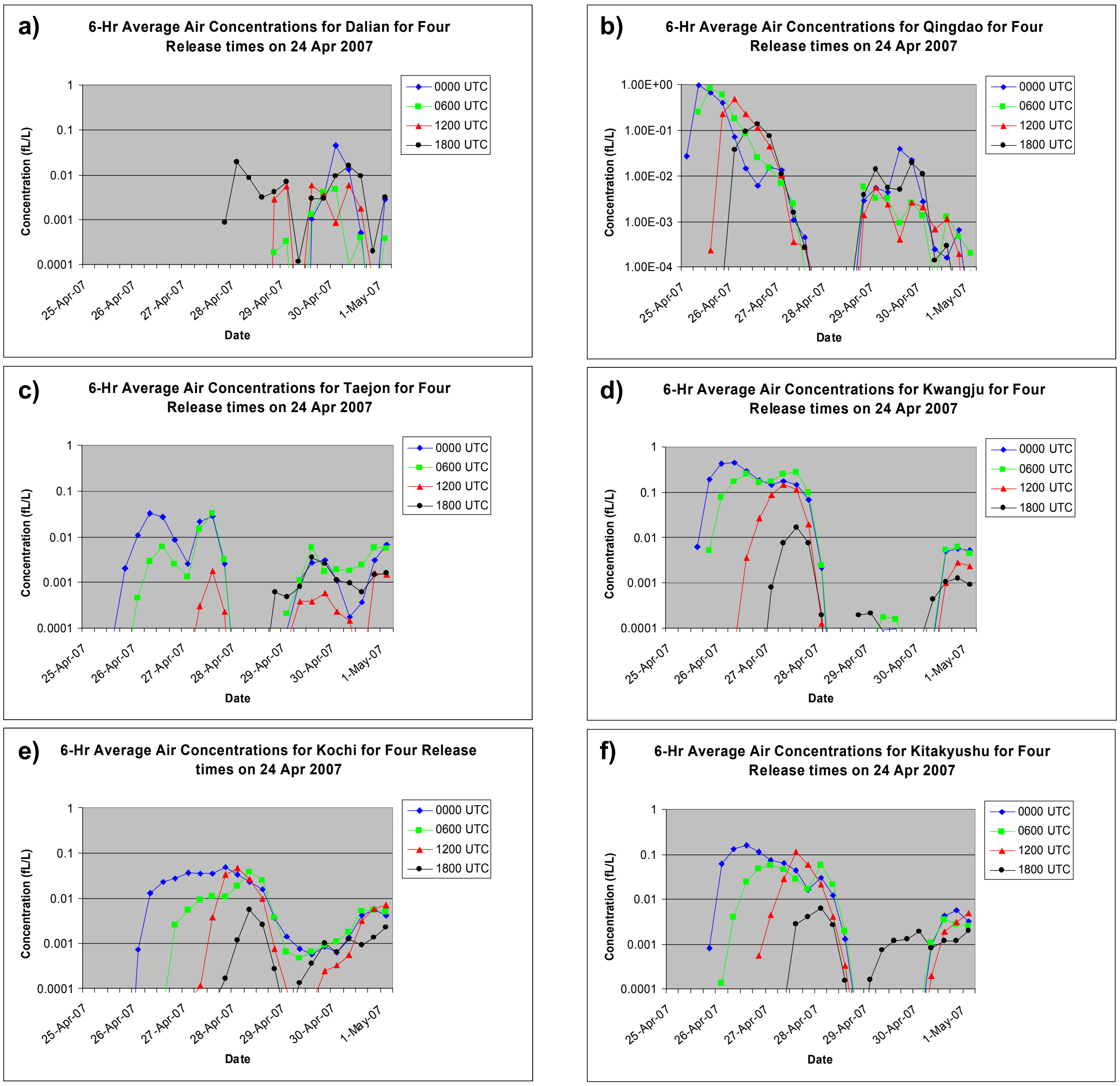

Figure 10a-f. Time-history of 6-hour average air concentrations at six sample cities for releases at 0000, 0600, 1200, and 1800 UTC on 24 April, 2007.

Time-history analysis of model computed air concentrations for 24 April sources continues to show model predicted values meeting long range experiment criteria that were attained with 22 and 23 April source times.

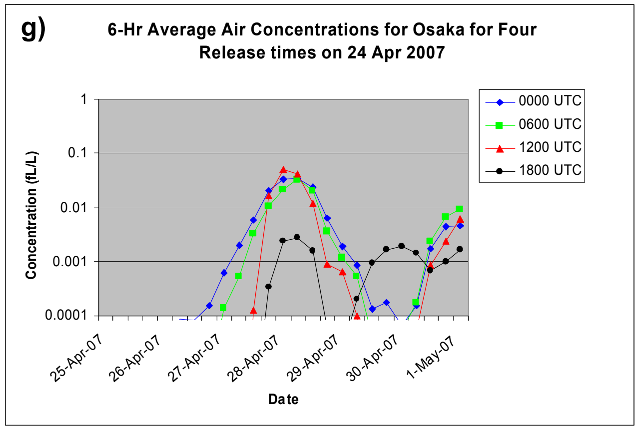

Figure 10g. Time-history of 6-hour average air concentrations at Osaka, Japan for releases at 0000, 0600, 1200, and 1800 UTC on 24 April, 2007.

Similar to the results for 23 April, data in eastern China show better model-predicted concentrations in Qingdao over Dalian. This is possibly due to the continued favorable pattern of the plume passing north of Dalian, but over Qingdao and significant portions of eastern China (not shown). However, maximum concentrations calculated for Qingdao (Fig 10b) show a consistent drop off for each successive run time after 0000 UTC. Note that a secondary peak is predicted to pass over Qingdao on 29 April, which is about the same time most of the highest values are computed at Dalian (Fig 10a) begin and is possibly associated with return flow noted in previous cases.

Time-history analysis of Kwangju (Fig 10d) are similar to Qingdao in showing a decreasing maximum value with later source times, the data also indicates the maximum value arrival delay is longer for the 1200 and 1800 source times. Values calculated for Taejon (Fig 10c) are much lower than for Kwangju, and suggests that the bulk of the plume possibly passed over the southern tip of the Korean Peninsula.

Unlike eastern China and South Korea, time-history data in Japan show similar highest computed air concentrations arriving at about the same time on 28 April for Kochi and Osaka (Fig 10e & g), but a spread in the arrival times for Kitakyushu (Fig 10f). Note that the chart for Kochi shows a fairly extended exposure to relatively high levels as early as 26 April, with the peak reached only on 28 April.

Table 19a & b show the source strength required to obtain a 12 fL/L measurement at the sample city based on the highest model computed 6-hr average air concentration for 0000, 0600 and 1200 UTC source times on 24 April.

Except for Dalian on 0600 and 1200 UTC and Taejon for 1200 UTC, source strengths of 500 kg are predicted to produce measurable PMCH air concentrations over all three regions of interest, as indicated in Table 20a & b.

Table 21 shows the arrival times in hours from the start of the release for the peak 6-hour average air concentration and the first greater than 2.0 fL/L.

Table 19a. Maximum concentration computed at any time for sample cities as well as the computed source strength required to get the computed value assuming a detection level of 12 fL/L PMCH, for the 0000 and 0600 UTC sources on 24 April 2007.

City	Max 6-Hr Ave Air Conc. for 0000 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)	Max 6-Hr Ave Air Conc. for 0600 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	4.42E-02	271	4.89E-03	2460
Qingdao	9.56E-01	13	8.29E-01	15
Taejon	3.26E-02	368	3.24E-02	370
Kwangju	4.56E-01	26	2.82E-01	43
Kitakyushu	1.59E-01	76	5.78E-02	208
Kochi	4.79E-02	250	3.85E-02	312
Osaka	3.45E-02	348	3.29E-02	365

Table 19b. Maximum concentration computed at any time for sample cities as well as the computed source strength required to get the computed value assuming a detection level of 12 fL/L PMCH, for the 1200 UTC source on 24 April 2007.

City	Max 6-Hr Ave Air Conc. for 1200 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	5.79E-03	2070
Qingdao	5.02E-02	239
Taejon	1.79E-03	6700
Kwangju	1.43E-01	84
Kitakyushu	1.13E-01	106
Kochi	4.61E-02	260
Osaka	5.02E-02	239

Table 20a. Computed measurements at each sample city given the source strength indicated, for 1200 and 1800 UTC sources on 24 April 2007.

	Measurement value computed for given source strength for 0000 UTC source (Values in fL/L)			Measurement value obtained for given source strength for 0600 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg	1000 Kg	500 kg	100 kg
Dalian	44	22	4*	5*	3*	<1*
Qingdao	956	478	96	829	415	83
Taejon	33	16	3*	32	16	3*
Kwangju	456	228	46	282	141	28
Kitakyushu	159	80	16	58	29	6*
Kochi	48	24	5*	39	19	4*
Osaka	35	17	3*	33	16	3*

*Value is below threshold of approximately 12 fL/L of PMCH

Table 20b. Computed measurements at each sample city given the source strength indicated, for 1200 UTC source on 24 April 2007.

	Measurement value computed for given source strength for 1200 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg
Dalian	6*	3*	<1*
Qingdao	50	25	5*
Taejon	2*	<1*	<1*
Kwangju	143	72	14
Kitakyushu	113	57	11*
Kochi	46	23	5*
Osaka	50	25	5*

*Value is below threshold of approximately 12 fL/L of PMCH

Table 21. Model computed arrival times of both peak 6-hour average and the first greater than 2.0 fL/L air concentration.

	0000 UTC source Arrival time (hrs)		0600 UTC source Arrival time (hrs)		1200 UTC source Arrival time (hrs)	
Concentration:	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak
Dalian	150	150	-	144	-	126
Qingdao	30	36	30	36	36	42
Taejon	54	60	84	84	78	78
Kwangju	48	60	48	84	60	72
Kitakyushu	54	66	60	72	72	78
Kochi	60	96	102	102	84	90
Osaka	96	108	96	102	90	90

May 2007 Results

Two separate periods during the month of May with screening-run releases on 10 May 1200 UTC and 11 May 0000 UTC, and also 23 May 1200 UTC to 24 May 1200 UTC respectively showed good or high model predicted potential to produce detectable levels in all three regions of interest.

Table 22. 24-hour average air concentrations from the screening runs in May 2007 where the weather pattern produced potentially detectable levels of PMCH tracer over all three countries of interest.

Date and Source Time (UTC)	All China (fL/L)	China three preferred cities (fL/L)	All Japan (fL/L)	Japan seven preferred cities (fL/L)	South Korea (fL/L)	Rank
10 May 1200	5.76E-02	8.00E-02	3.18E-02	4.67E-02	8.91E-02	Good
11 May 0000	4.41E-02	9.52E-03	1.66E-02	2.42E-02	6.98E-02	Good
23 May 1200	7.80E-02	3.23E-02	1.79E-02	1.79E-02	2.97E-02	Good
24 May 0000	4.57E-02	7.90E-02	5.54E-02	7.10E-02	5.27E-02	High
24 May 1200	8.47E-02	1.59E-01	2.21E-02	2.58E-02	6.90E-02	High

See Appendix A for a summary of the 24-hour average air concentration results for all days in May.

Detailed case studies were made for 09 May 1800 UTC, 0000, 0600, 1200, 1800 UTC on 10 May, and 0000 and 0600 UTC on 11 May. And also for 0600, 1200, 1800 on 23 May, 0000, 0600, 1200, and 1800 UTC on 24 May.

NARAC Model Results for 10 May, 2007, 1200 UTC Case

This case is the first case of the first of two periods in May that model calculations project could meet the screening criteria. For this case detailed model runs were made for 0000, 0600, and 1200 UTC on 10 May.

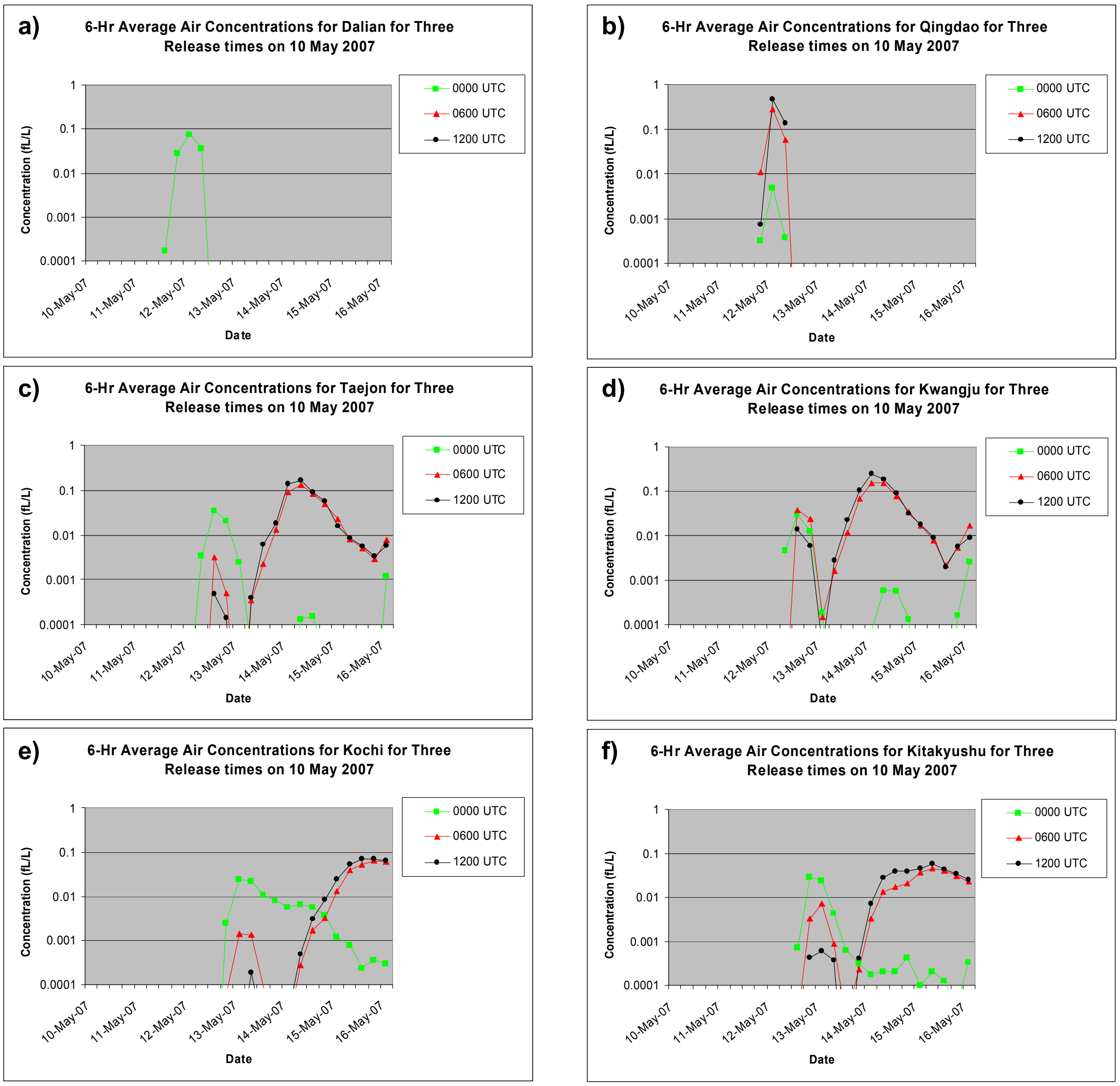

Figure 11a-f. Time-history of 6-hour average air concentrations at six sample cities for releases at 0000, 0600, and 1200 UTC on 10 May, 2007.

Time-history analysis for eastern China show only a brief period of exposure for both Dalian and Qingdao (Fig 11a & b), and then only for the 0000 UTC source time for Dalian. Exposure times are predicted to be very short, only for an 18 hour period beginning on 12 May.

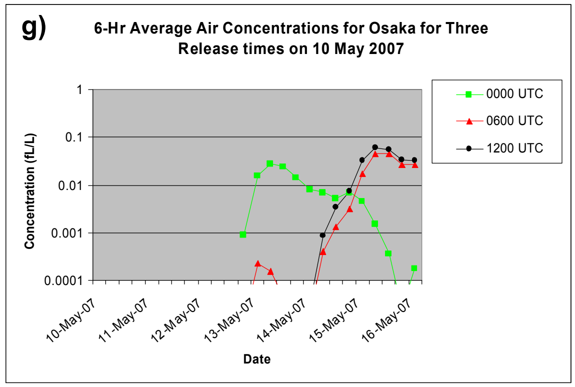

Figure 11g. Time-history of 6-hour average air concentrations at Osaka, Japan for releases at 0000, 0600 and 1200 UTC on 10 May, 2007.

The pattern of the model predicted concentrations are different for South Korea, with a weaker peak at the end of 12 May for both Kwangju and Taejon (Fig 11c & d), followed by a much higher predicted concentration over 0.1 fL/L on 10 May, particularly for the 0600 and 1200 UTC source times. For both cities the 0000 UTC source time produces lower concentrations around 0.05 fL/L.

Time-history charts for Japan have a similar pattern to the charts in South Korea. Kochi, Kitakyushu, and Osaka (Fig 11e-g) each show a weak initial peak on 13 May, followed by higher model-computed 6-hr average air concentrations on 14-15 May. Model predicted concentrations are approximately three times higher for the 0600 and 1200 UTC source time over the 0000 UTC time.

Table 23 shows the source strength needed to reach a detectable level for the highest computed concentration at a sample city. Except for Dalian for the 1200 UTC source time, source strengths of only a few hundred kg of PMCH might produce detectable levels in all three regions of interest.

Table 23. Maximum concentration computed at any time for sample cities as well as the computed source strength required to get the computed value assuming a detection level of 12 fL/L PMCH, for the 0600 and 1200 UTC sources on 10 May 2007.

City	Max 6-Hr Ave Air Conc. for 0600 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)	Max 6-Hr Ave Air Conc. for 1200 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	-	-	-	-
Qingdao	2.75E-01	44	4.64E-01	26
Taejon	1.31E-01	92	1.68E-01	71
Kwangju	1.57E-01	77	2.44E-01	49
Kitakyushu	4.41E-02	272	5.60E-02	214
Kochi	6.34E-02	189	7.06E-02	170
Osaka	4.47E-02	268	6.08E-02	197

Table 24 below summarizes the model computed measurements at the sample cities for three source strengths. Results for the 0600 and 1200 UTC release time on 10 May are indicated.

Table 25 shows the arrival times in hours from the start of the release for the peak 6-hour average air concentration and the first greater than 2.0 fL/L.

Table 24. Computed measurements at each sample city given the source strength indicated, for 0600 and 1200 UTC sources on 10 May 2007.

	Measurement value computed for given source strength for 0600 UTC source (Values in fL/L)			Measurement value obtained for given source strength for 1200 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg	1000 Kg	500 kg	100 kg
Dalian	-	-	-	-	-	-
Qingdao	275	138	28	464	232	46
Taejon	131	66	13	168	84	17
Kwangju	157	79	16	244	122	24
Kitakyushu	44	22	4*	56	28	6*
Kochi	63	32	6*	71	35	7*
Osaka	45	22	4*	61	30	6*

*Value is below threshold of approximately 12 fL/L of PMCH

Table 25. Model computed arrival times of both peak 6-hour average and the first greater than 2.0 fL/L air concentration.

	0600 UTC source Arrival time (hrs)		1200 UTC source Arrival time (hrs)	
Concentration:	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak
Dalian	-	-	-	-
Qingdao	48	48	42	42
Taejon	96	102	90	96
Kwangju	60	102	78	90
Kitakyushu	114	126	96	120
Kochi	126	138	114	126
Osaka	126	132	114	120

NARAC Model Results for 11 May, 2007, 0000 UTC Case

This case is the second case of the first period in May that model calculations project could meet the screening criteria. For this case detailed model runs were made for 10 May 1800 UTC, plus 0600 and 1200 UTC on 11 May.

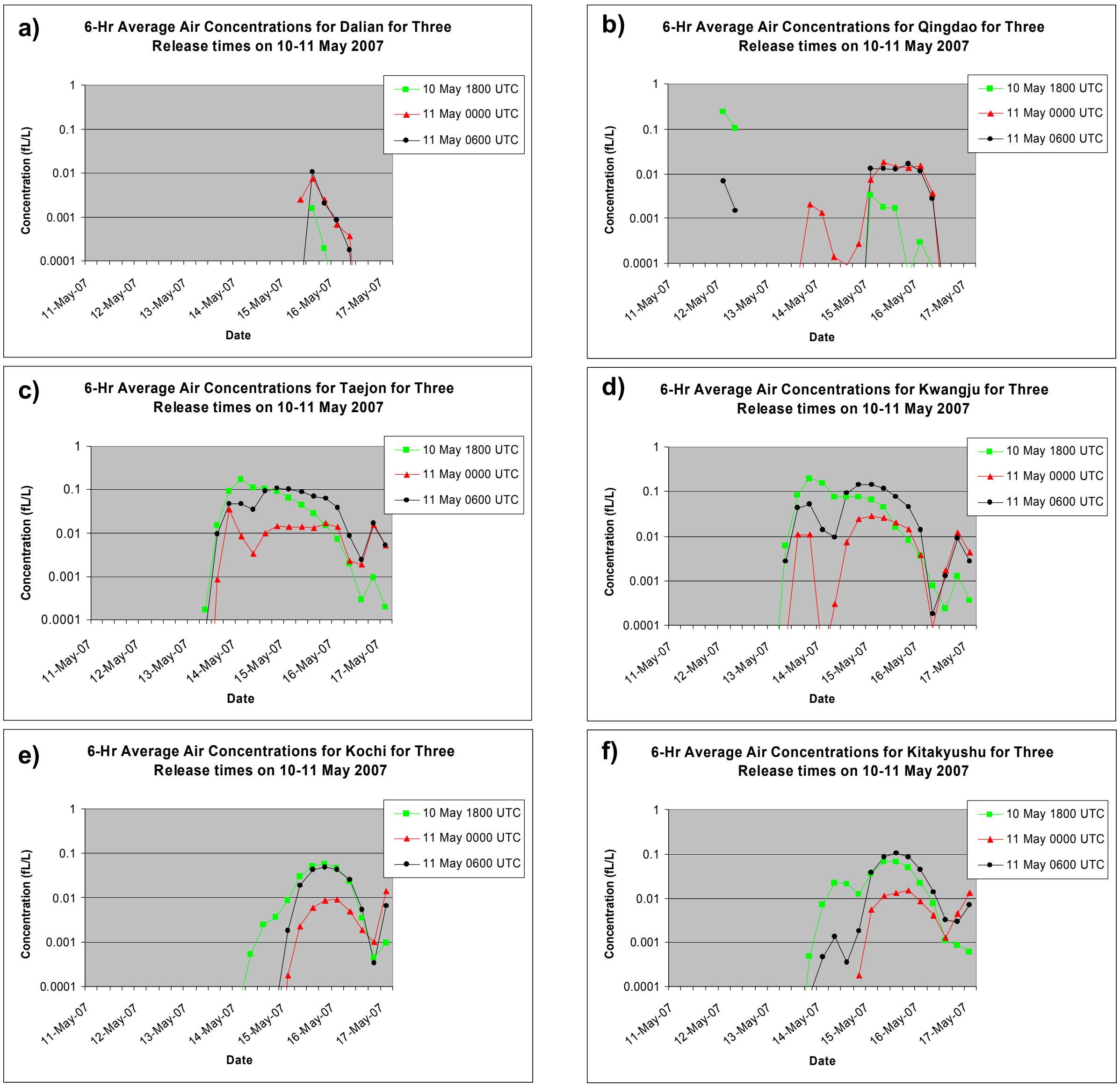

Figure 12a-f. Time-history of 6-hour average air concentrations at six sample cities for releases at 10 May 1800 UTC, plus 0600 and 1200 UTC on 11 May, 2007.

The time-history chart for Qingdao (Fig 12b) shows a very brief initial plume passage of only 12 hours on 12 May with relatively high concentrations predicted for the 10 May 1800 UTC and 11 May 0600 UTC source times. Secondary peaks are also evident for both cities in eastern China, beginning on 15-16 May, possibly due to return flow. Concentrations in Dalian (Fig 12a) are lower for this second peak than at Qingdao.

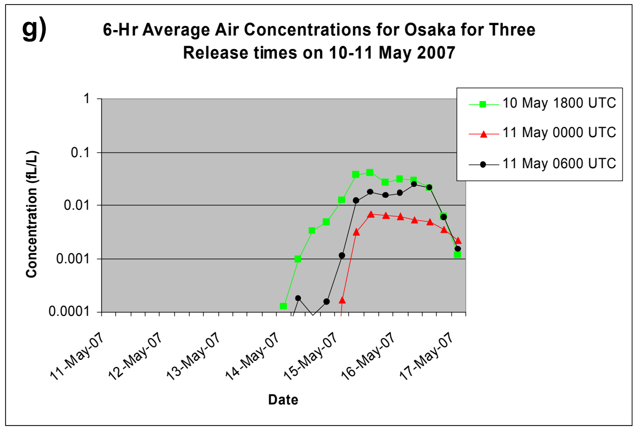

Figure 12g. Time-history of 6-hour average air concentrations at Osaka, Japan for releases at 10 May 1800 UTC, plus 0600 and 1200 UTC on 11 May, 2007.

Time-history charts for Kwangju and Taejon (Fig 12c & d) show a somewhat extended higher model predicted concentrations beginning on 13 May, and lasting through 15 May, although data for Taejon shows a brief decrease in concentrations on 14 May. Concentrations are predicted to be highest for the first two source times of this case in South Korea.

Model predicted 6-hr average air concentrations in Japan (Fig 12e-g) show mostly a single peak arriving on 15 May, although a fairly high initial peak is indicated in the data for Kitakyushu arriving on 14 May for the 1800 UTC May 10 source time. Similarly to the relative magnitudes in South Korea, the model predicted concentrations are predicted to be higher for the 10 May 1800 UTC and 11 May 0000 UTC source times.

Table 26. Maximum concentration computed at any time for sample cities as well as the computed source strength required to get the computed value assuming a detection level of 12 fL/L PMCH, for 10 May 1800 UTC and 11 May 0600 UTC sources.

City	Max 6-Hr Ave Air Conc. for 10 May 1800 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)	Max 6-Hr Ave Air Conc. for 11 May 0000 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	1.59E-03	7540	1.02E-02	1170
Qingdao	2.40E-01	50	1.66E-02	721
Taejon	1.77E-01	68	1.06E-01	113
Kwangju	1.97E-01	61	1.44E-01	84
Kitakyushu	6.79E-02	177	1.05E-01	114
Kochi	5.86E-02	205	4.86E-02	247
Osaka	4.22E-02	284	2.44E-02	491

Table 26 shows the source strength needed to reach a detectable level for the highest computed concentration at a sample city. Except for Dalian, source strengths of only a few hundred kg of PMCH might produce detectable levels in all three regions of interest.

Table 27 below summarizes the model computed measurements at the sample cities for three source strengths. Results for the 10 May 1800 UTC and 11 May 0600 UTC source times are indicated.

Table 28 shows the arrival times in hours from the start of the release for the peak 6-hour average air concentration and the first greater than 2.0 fL/L.

Table 27. Computed measurements at each sample city given the source strength indicated, for 10 May 1800 UTC and 11 May 0600 UTC sources.

	Measurement value computed for given source strength for 1800 UTC 10 May 2007 source (Values in fL/L)			Measurement value obtained for given source strength for 0600 UTC 11 May 2007 source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg	1000 Kg	500 kg	100 kg
Dalian	2*	<1*	<1*	10*	5*	1*
Qingdao	240	120	24	17	8*	2*
Taejon	177	89	18	106	53	11*
Kwangju	197	99	20	144	72	14
Kitakyushu	68	34	7*	105	53	11*
Kochi	59	29	6*	49	24	5*
Osaka	42	21	4*	24	12	2*

*Value is below threshold of approximately 12 fL/L of PMCH

Table 28. Model computed arrival times of both peak 6-hour average and the first greater than 2.0 fL/L air concentration.

	1800 UTC 10 May source Arrival time (hrs)		0600 UTC 11 May source Arrival time (hrs)	
Concentration:	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak
Dalian	-	114	-	108
Qingdao	30	30	-	108
Taejon	72	78	60	84
Kwangju	66	72	54	126
Kitakyushu	84	114	90	102
Kochi	108	120	102	108
Osaka	108	114	120	120

NARAC Model Results for 23 May, 2007, 1200 UTC Case

This case is the first case of the second of two periods in May that model calculations project could meet the screening criteria. For this case detailed model runs were made for 0600, 1200, and 1800 UTC on 23 May.

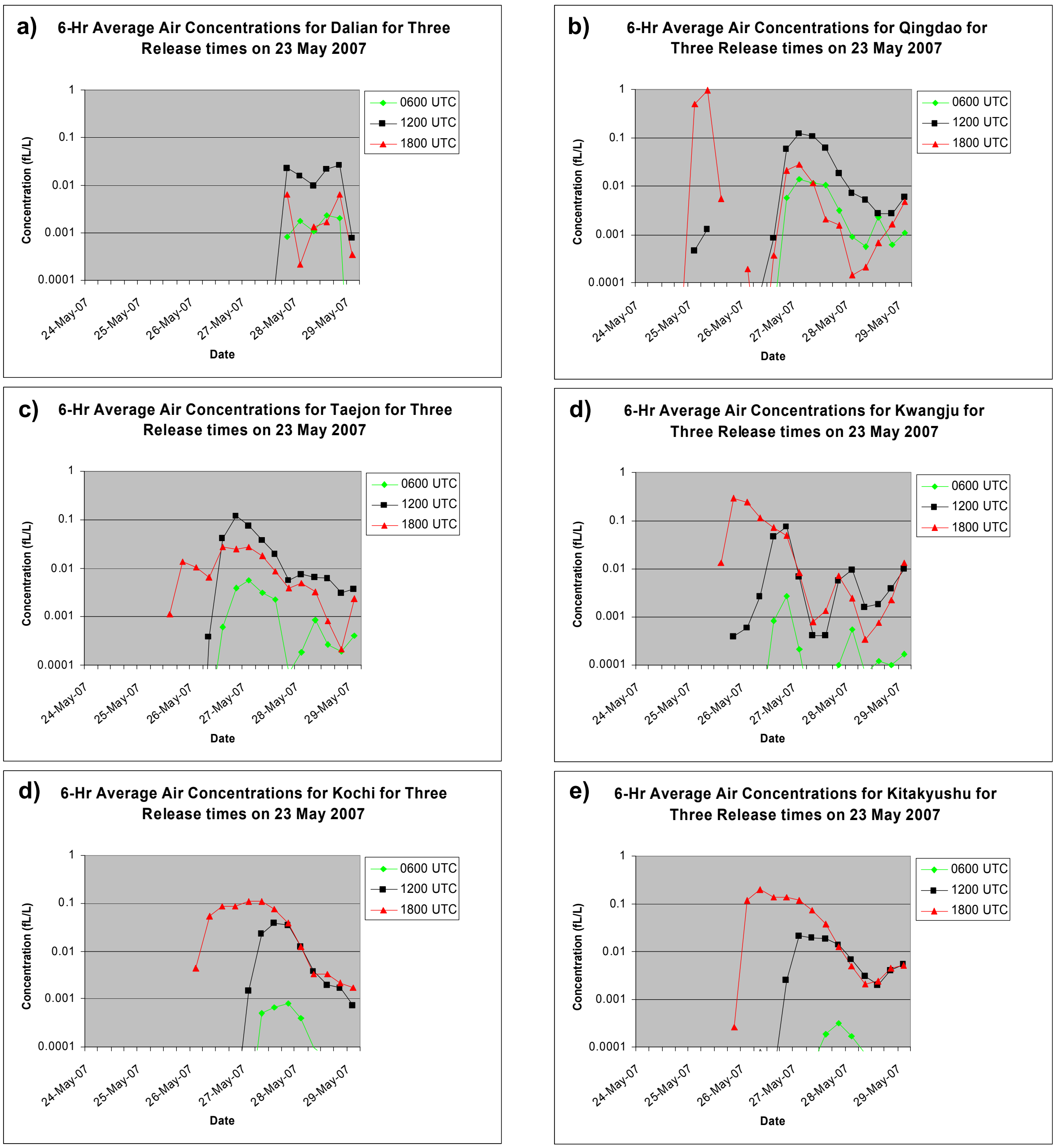

Figure X13a-f. Time-history of 6-hour average air concentrations at six sample cities for releases at 0600, 1200, and 1800 UTC on 23 May, 2007.

The time-history chart for Qingdao (Fig 13b) shows a very similar pattern to the May 11 case with a sharp spike of relatively high model predicted air concentrations within a day or two of the source start time, followed by a secondary peak a few days later. The initial peak is particularly higher for the 1800 UTC release time and much lower for the 1200 UTC time. Model predicted concentrations are relatively high for the secondary peak at Qingdao beginning on 27 May. A relatively low secondary peak is the first model predicted arrival on 28 May of air concentrations for all three source times at Dalian (Fig 13a).

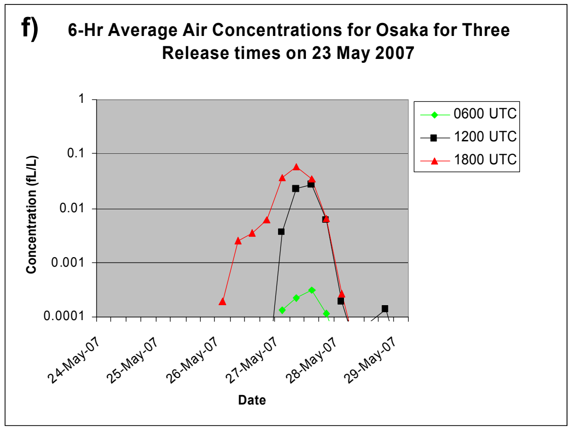

Figure 13g. Time-history of 6-hour average air concentrations at Osaka, Japan for releases at 0600, 1200, and 1800 UTC on 23 May, 2007.

Time-history charts for Kwangju and Taejon (Fig 13c & d) show a relatively noisy pattern with multiple peaks evident, but model predicted concentrations for source times for 1200 and 1800 UTC are significantly higher than the 0600 UTC source. It is interesting to note that model predicted arrival time of material from the latest release time of 1800 UTC arrives first at both cities in South Korea. The arrival time is a full 18 hours earlier for Taejon, and 6 hours earlier than the 1200 UTC source time for Kwangju.

Analysis of the time-history charts in Japan (Fig 14e-g) show a fairly distinct peak arriving at all three cities, but similarly for the South Korea, the 1800 UTC source time concentrations arrive first on 26 May. Model predicted arrival time for the 1200 UTC release is 27 May for all three cities in Japan. Data for Kochi, Kitakyushu, and Osaka show significantly higher model predicted air concentrations for the 1200 and 1800 UTC sources over the 0600 UTC source time.

Table 29 shows the source strength needed to reach a detectable level for the highest computed concentration at a sample city. Except for Dalian and the 1800 UTC source time, source strengths of only a few hundred kg of PMCH might produce detectable levels in all three regions of interest.

Table 30 below summarizes the model computed measurements at the sample cities for three source strengths. Results for 1200 and 1800 UTC source times for 23 May are indicated.

Table 31 shows the arrival times in hours from the start of the release for the peak 6-hour average air concentration and the first greater than 2.0 fL/L.

Table 29. Maximum concentration computed at any time for sample cities as well as the computed source strength required to get the computed value assuming a detection level of 12 fL/L PMCH, for 1200 and 1800 UTC 23 May sources.

City	Max 6-Hr Ave Air Conc. for 1200 UTC (fL/L)	Source Strength needed for 12 fL/L detection level (kg)	Max 6-Hr Ave Air Conc. for 1800 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	2.68E-02	448	6.46E-03	1860
Qingdao	1.23E-01	97	9.40E-01	13
Taejon	1.21E-01	99	2.71E-02	443
Kwangju	7.71E-02	156	2.97E-01	40
Kitakyushu	2.16E-02	555	1.94E-01	62
Kochi	3.91E-02	307	1.09E-01	110
Osaka	2.78E-02	432	5.80E-02	207

Table 30. Computed measurements at each sample city given the source strength indicated, for 1200 and 1800 UTC 23 May sources.

	Measurement value computed for given source strength for 1200 UTC source (Values in fL/L)			Measurement value obtained for given source strength for 1800 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg	1000 Kg	500 kg	100 kg
Dalian	27	13	3*	6*	3*	>1*
Qingdao	123	62	12	940	470	94
Taejon	121	61	12	27	14	3*
Kwangju	77	39	8*	297	149	30
Kitakyushu	22	11*	2*	194	97	19
Kochi	39	20	4*	109	55	11*
Osaka	28	14	7*	58	29	6*

*Value is below threshold of approximately 12 fL/L of PMCH

Table 31. Model computed arrival times of both peak 6-hour average and the first greater than 2.0 fL/L air concentration.

	1200 UTC source Arrival time (hrs)		1800 UTC source Arrival time (hrs)	
Concentration:	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak
Dalian	108	132	-	96
Qingdao	78	84	30	36
Taejon	72	78	66	66
Kwangju	72	78	48	48
Kitakyushu	84	84	54	60
Kochi	90	96	60	78
Osaka	90	96	78	84

NARAC Model Results for 24 May, 2007, 0000 and 1200 UTC Case

This case is the last case in May, and last case examined overall, where model calculations project could meet the screening criteria. For this case detailed model runs were made for 0000, 0600, 1200, and 1800 UTC on 24 May.

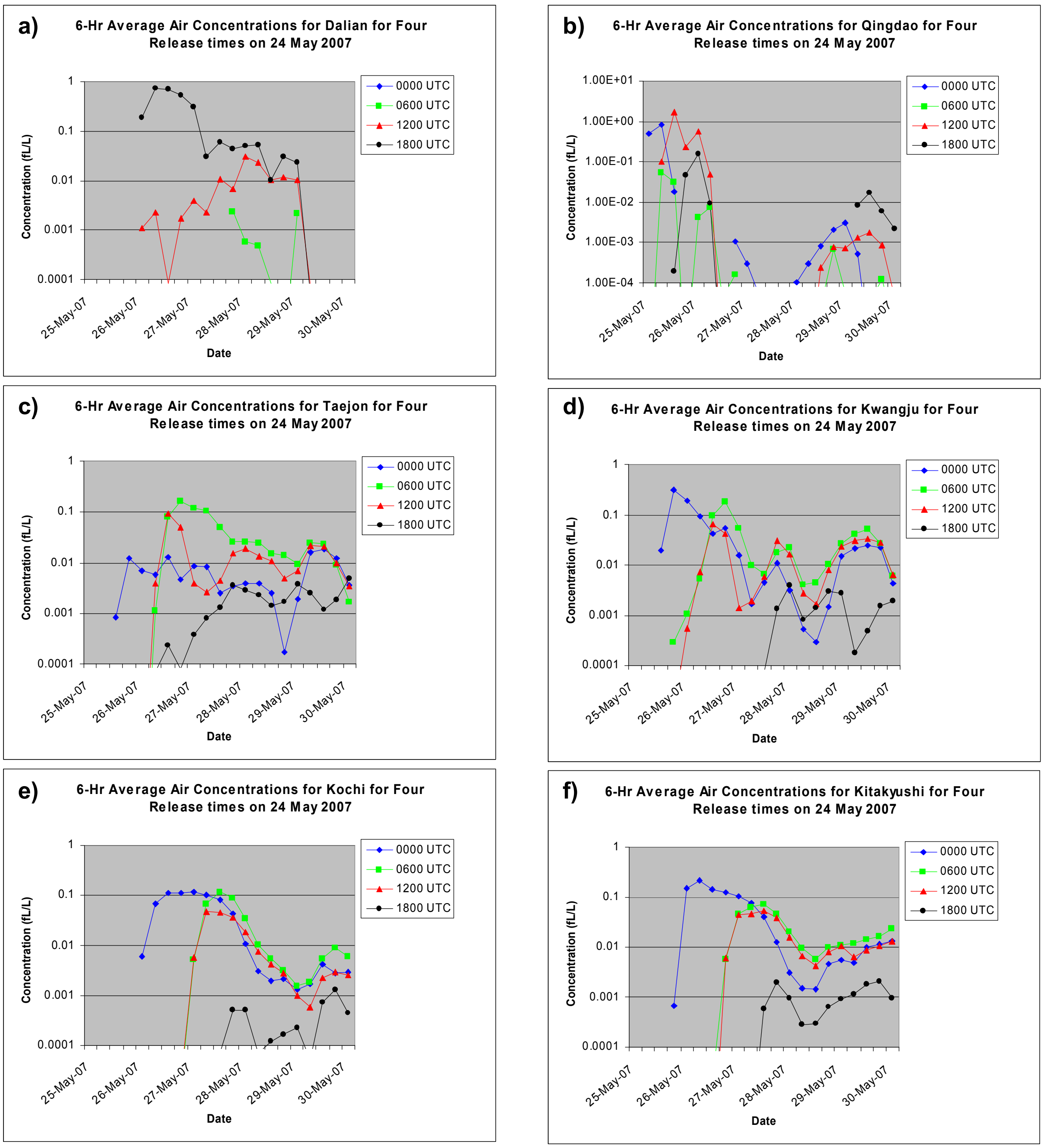

Figure 14a-f. Time-history of 6-hour average air concentrations at six sample cities for releases at 0000, 0600, 1200, and 1800 UTC on 24 May, 2007.

Time-history charts for eastern China show different results. Data for Dalian (Fig 14a) shows relatively high model predicted air concentrations on 26 May for the 1800 UTC source time. Note that this is the only sample city that the 1800 UTC source time produced the highest concentrations of all four source times.

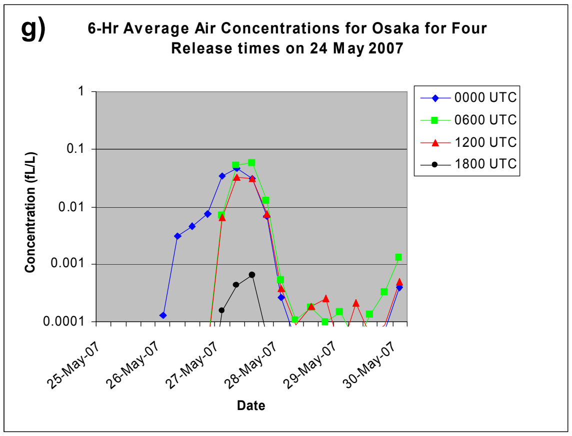

Figure 14g. Time-history of 6-hour average air concentrations at Osaka, Japan for releases at 0000, 0600, 1200, and 1800 UTC on 24 May, 2007.

Qingdao's time-history chart (Fig 14b) shows relatively early model predicted arrival of the plume within the first day, on 25 May. Additionally, the highest model predicted air concentration for either Qingdao or Dalian for this entire study were produced by the 1200 UTC source case with a predicted value of over 1 fL/L for a 6-hour average. After 26 May model predicted concentrations drop below significant levels.

Time-history charts for both Kwangju and Taejon (Fig 14c & d) show a noisy pattern of multiple peaks and also a fairly quick arrival time compared to other cases in this study. Model predicted concentrations are consistently high for the 0600 and 1200 UTC source times for both cities, but highest for the 0000 UTC source at Taejon. Several potentially detectable levels of PMCH are predicted to occur during this run at both cities.

Time-history data for all three cities in Japan (Fig 14e-g) show a similar pattern. Model predicted arrival for the 0000 UTC source is just about 48 hours on 26 May, followed about a day later by the arrival of the 0600 and 1200 UTC sources. The 0000 UTC source produces highest predicted concentration Kitakyushu where the maximum predicted concentration is about the same for all three source times at Kochi and Osaka.

Table 32a & b show the source strength required to obtain a 12 fL/L measurement at the sample city based on the highest model computed 6-hr average air concentration for 0000, 0600 and 1200 UTC source times on 24 May. Note that the model predicts that only 7 kg of PMCH would need to be released for the 1200 UTC source to produce a detectable level at Qingdao.

Except for Dalian on 0600 and 1200 UTC source strengths of 500 kg are predicted to produce measurable PMCH air concentrations over all three regions of interest, as indicated in Table 33a & b.

Table 34 shows the arrival times in hours from the start of the release for the peak 6-hour average air concentration and the first greater than 2.0 fL/L.

Table 32a. Maximum concentration computed at any time for sample cities as well as the computed source strength required to get the computed value assuming a detection level of 12 fL/L PMCH, for the 0000 and 0600 UTC sources on 24 May 2007.

City	Max 6-Hr Ave Air Conc. for 0000 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)	Max 6-Hr Ave Air Conc. for 0600 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	-	-	2.43E-03	4940
Qingdao	8.47E-01	14	5.50E-02	218
Taejon	1.78E-02	675	1.68E-01	72
Kwangju	3.06E-01	39	1.84E-01	65
Kitakyushu	2.11E-01	57	7.13E-02	168
Kochi	1.15E-01	104	1.15E-01	105
Osaka	4.72E-02	254	5.91E-02	203

Table 32b. Maximum concentration computed at any time for sample cities as well as the computed source strength required to get the computed value assuming a detection level of 12 fL/L PMCH, for the 1200 UTC source on 24 May 2007.

City	Max 6-Hr Ave Air Conc. for 1200 UTC Source (fL/L)	Source Strength needed for 12 fL/L detection level (kg)
Dalian	3.00E-02	400
Qingdao	1.75E+00	7
Taejon	9.44E-02	127
Kwangju	6.61E-02	181
Kitakyushu	5.34E-02	225
Kochi	4.71E-02	255
Osaka	3.30E-02	363

Table 33a. Computed measurements at each sample city given the source strength indicated, for the 0000 and 0600 UTC sources on 24 May 2007.

	Measurement value computed for given source strength for 0000 UTC source (Values in fL/L)			Measurement value obtained for given source strength for 0600 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg	1000 Kg	500 kg	100 kg
Dalian	-	-	-	2*	>1*	>1*
Qingdao	847	424	85	55	28	6*
Taejon	18	9*	2*	168	84	17
Kwangju	306	153	31	184	92	18
Kitakyushu	211	106	21	71	36	7*
Kochi	115	58	12	115	58	12
Osaka	47	24	5*	59	30	6*

*Value is below threshold of approximately 12 fL/L of PMCH

Table 33b. Computed measurements at each sample city given the source strength indicated, for 1200 UTC source on 24 May 2007.

	Measurement value computed for given source strength for 1200 UTC source (Values in fL/L)		
Source:	1000 Kg	500 kg	100 kg
Dalian	30	15	3*
Qingdao	1750	875	175
Taejon	94	47	9*
Kwangju	66	33	7*
Kitakyushu	53	27	5*
Kochi	47	24	5*
Osaka	33	17	3*

*Value is below threshold of approximately 12 fL/L of PMCH

Table 34. Model computed arrival times of both peak 6-hour average and the first greater than 2.0 fL/L air concentration.

	0000 UTC source Arrival time (hrs)		0600 UTC source Arrival time (hrs)		1200 UTC source Arrival time (hrs)	
Concentration:	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak	> 2.0 fL/L	Peak
Dalian	-	-	-	84	90	90
Qingdao	24	30	24	24	18	18
Taejon	-	132	54	60	48	48
Kwangju	42	42	54	60	48	48
Kitakyushu	48	54	66	78	60	72
Kochi	54	72	72	78	66	66
Osaka	72	78	72	78	66	66

Summary

180 screening runs from 01 March through 29 May 2007 were made with a normalized 1 kg source of PMCH released from Taiyuan China. NARAC used the GFS global model for wind input and a modeling domain large enough to cover the eastern China and the western Pacific. Subsequent detailed analysis of model predicted air concentrations over Eastern China, South Korea, and Japan identified 14 potential release cases with good or high probability of producing detectable levels of PMCH over all three regions.

The model predicted that a reasonable amount of PCMH on the order of 500 kg would be needed to achieve the long range experiment goal over eastern China, South Korea, and Japan. This value is similar to the amount released during the ETEX second experiment[5].

Four of the 14 cases occurred in March, and five each in April and May. All 14 cases occurred over 10 days in six distinct groups. Four of these six groups showed sequential 12-hour periods of favorable results, possibly indicating favorable weather patterns can develop with a window of one or more dates to conduct releases. Of the 90 days studied, only 10 were shown by model predictions to achieve experiment objectives, or 11%. Individual cases of 12 hour periods indicate 14 of 180 or 7.8% chance to achieve experiment objectives.

Favorable cases occurred during the months of March through May 2007 approximately every 13.8 days, with a minimum time of five days between favorable cases (19 March to 24 March) and a maximum of 29 days (24 March to 22 April). However, of the 90 days studied

This study was designed to identify favorable dates and times to produce the experiment objective of producing detectable PMCH air concentrations in eastern China, South Korea, and western Japan. These dates would then be analyzed by local weather experts to quantify the weather patterns that produced them. These favorable weather patterns could be catalogued and used during a future long range experiment release window to predict specific release times. Conversely, particularly adverse release dates could be analyzed to forecast times not to release material during the experiment.

This study used analyzed winds from a global forecast model, and was limited to running simulations for actual weather patterns that materialized during the study period. There is no assurance that all favorable weather patterns occurred during the study, or any weather pattern that developed in the spring of 2007 will occur in 2008 or any future spring period a long range tracer experiment is run.

References:

1. Kalnay, M. Kanamitsu, and W.E. Baker, 1990: *Global numerical weather prediction at the National Meteorological Center.* Bull. Amer. Meteor. Soc., 71, 1410-1428.
2. G. Sugiyama and S.T. Chan, 1997: *A New Meteorological Data Assimilation Model for Real-Time Emergency Response*. Lawrence Livermore National Laboratory, UCRL-JC-127579
3. John M. Leone, Jr., J. S. Nasstrom, D. M. Maddix, D. J. Larson, G. Sugiyama and D. L. Ermak, 2001: *Langrangian Operational Dispersion Integrator (LODI) User's Guide Version 1.0*. Lawrence Livermore National Laboratory, UCRL-AM-212798
4. Watson, T. B., Wilke, R., Dietz, R. N., Heiser, J., and Kalb, P., 2007: *The Atmospheric Background of Perflourocarbon Compounds Used as Tracers*. Brookhaven National Laboratory Formal Report, In Review.
5. Nodkop K., Connolly R., and Girardi F., 1998: *The field campaigns of the European Tracer Experiment (ETEX) - sampling and analysis.* Atmospheric Environment, pp 4095-4108

Appendix 1. 24-Hour Average Air Concentration Result Summary

Table 1. 24-hour average air concentrations in March 2007 for 1 kg normalized 0000 and 1200 UTC screening release times.

Date and Source Time (UTC)	Case Grade[1]	All China (fL/L)	China three preferred cities (fL/L)	All Japan (fL/L)	Japan seven preferred cities (fL/L)	South Korea (fL/L)
1 Mar 0000	Bad	1.31E-02	-	-	-	-
1 Mar 1200	Bad	1.54E-02	-	6.23E-04	-	-
2 Mar 0000	Bad	1.31E-04	-	1.41E-04	1.18E-04	-
2 Mar 1200	Bad	4.35E-02	-	1.60E-04	1.83E-04	-
3 Mar 0000	Bad	2.27E-01	-	5.38E-04	-	-
3 Mar 1200	Bad	8.18E-03	-	-	-	-
4 Mar 0000	Bad	2.39E-02	-	-	-	-
4 Mar 1200	Bad	9.39E-02	2.74E-03	-	-	3.18E-05
5 Mar 0000	Low	3.25E-02	2.61E-02	9.83E-04	1.36E-03	3.10E-03
5 Mar 1200	Low	1.19E-01	2.31E-02	2.55E-03	3.86E-03	7.39E-03
6 Mar 0000	Low	9.07E-02	4.88E-02	1.94E-03	2.52E-03	1.03E-02
6 Mar 1200	Poor	1.84E-02	3.07E-02	1.93E-04	1.52E-04	1.34E-04
7 Mar 0000	Poor	3.49E-02	3.49E-02	2.84E-04	1.09E-04	6.55E-03
7 Mar 1200	Poor	3.31E-02	5.47E-02	1.67E-04	1.38E-04	6.82E-04
8 Mar 0000	Poor	1.27E-02	2.30E-02	4.16E-04	4.45E-04	9.85E-04
8 Mar 1200	Poor	4.17E-03	4.28E-03	6.12E-04	6.20E-04	1.18E-03
9 Mar 0000	Bad	6.34E-03	-	5.50E-04	-	-
9 Mar 1200	Bad	1.33E-02	5.46E-03	-	-	-
10 Mar 0000	Low	3.76E-02	6.57E-02	2.85E-03	3.24E-03	4.68E-02
10 Mar 1200	High	7.80E-02	1.46E-01	1.19E-02	1.36E-02	8.18E-02
11 Mar 0000	Low	3.61E-02	5.11E-03	1.10E-03	1.23E-03	1.13E-02
11 Mar 1200	Bad	2.82E-02	5.67E-04	-	-	1.80E-5
12 Mar 0000	Bad	6.90E-03	5.35E-03	-	-	-
12 Mar 1200	Bad	2.25E-05	2.25E-05	-	-	-
13 Mar 0000	Bad	-	-	-	-	-
13 Mar 1200	Bad	-	-	-	-	-
14 Mar 0000	Bad	7.00E-04	7.00E-04	-	-	-
14 Mar 1200	Bad	-	-	6.43E-05	-	-
15 Mar 0000	Bad	4.19E-04	3.61E-05	-	-	-
15 Mar 1200	Bad	4.02E-04	5.01E-04	-	-	-
16 Mar 0000	Bad	7.26E-03	1.46E-03	1.39E-04	-	2.48E-05
16 Mar 1200	Bad	1.37E-03	-	-	-	5.53E-05
17 Mar 0000	Bad	1.59E-04	-	1.69E-05	1.32E-05	1.51E-04
17 Mar 1200	Poor	5.23E-02	5.23E-02	9.00E-04	9.00E-04	1.24E-05
18 Mar 0000	Low	6.21E-03	6.21E-03	7.58E-03	8.66E-03	3.79E-03
18 Mar 1200	Poor	1.21E-01	1.21E-01	6.97E-04	7.82E-04	1.73E-04

Table 1 (continued). 24-hour average air concentrations in March 2007 for all regions of interest for both 0000 and 1200 UTC screening release times.

Date and Source Time (UTC)	Case Grade[1]	All China (fL/L)	China three preferred cities (fL/L)	All Japan (fL/L)	Japan seven preferred cities (fL/L)	South Korea (fL/L)
19 Mar 0000	Low	1.96E-01	1.96E-01	4.86E-03	5.60E-03	1.99E-03
19 Mar 1200	Good	7.03E-03	7.03E-03	7.65E-03	9.38E-03	2.14E-03
20 Mar 0000	Low	6.30E-03	6.30E-03	6.16E-03	6.34E-03	5.28E-03
20 Mar 1200	Bad	1.83E-03	1.83E-03	2.60E-04	2.09E-04	-
21 Mar 0000	Bad	2.74E-04	2.74E-04	-	-	-
21 Mar 1200	Bad	-	-	-	-	-
22 Mar 0000	Bad	-	-	-	-	-
22 Mar 1200	Poor	1.69E-02	1.82E-02	1.41E-03	1.66E-03	4.51E-03
23 Mar 0000	Low	1.61E-02	2.45E-02	2.07E-03	2.79E-03	1.43E-02
23 Mar 1200	Low	8.82E-02	5.32E-02	6.03E-03	7.74E-03	1.23E-02
24 Mar 0000	Good	2.80E-03	4.69E-03	8.42E-03	1.17E-02	7.82E-03
24 Mar 1200	Good	1.04E-02	1.90E-02	8.93E-03	1.14E-02	1.25E-02
25 Mar 0000	Poor	1.42E-04	2.31E-04	8.86E-05	8.86E-05	2.80E-04
25 Mar 1200	Low	3.11E-03	1.56E-03	5.85E-03	6.14E-03	8.43E-03
26 Mar 0000	Low	5.25E-03	1.16E-02	2.17E-03	2.17E-03	2.21E-03
26 Mar 1200	Low	3.70E-03	5.75E-03	4.25E-03	3.92E-03	2.46E-03
27 Mar 0000	Poor	5.15E-03	7.16E-03	8.92E-04	9.95E-04	1.81E-03
27 Mar 1200	Low	4.34E-03	5.17E-03	3.16E-03	4.05E-03	7.41E-03
28 Mar 0000	Poor	6.27E-04	8.37E-04	1.21E-04	1.21E-04	3.27E-04
28 Mar 1200	Low	5.34E-03	3.90E-03	7.54E-03	9.67E-03	2.78E-03
29 Mar 0000	Poor	3.58E-04	1.23E-03	9.89E-04	1.29E-03	5.85E-04
29 Mar 1200	Poor	3.14E-04	3.57E-04	5.26E-04	6.17E-04	1.77E-03
30 Mar 0000	Bad	3.57E-02	-	2.03E-04	2.03E-04	-
30 Mar 1200	Bad	7.52E-02	-	-	-	-
31 Mar 0000	Bad	2.80e-02	-	-	-	-
31 Mar 1200	Bad	6.58E-02	-	-	-	-

Notes:
1. Cases have been graded from Bad to High in a qualitative manner to estimate the chance that the release for that date in time could produce detectable levels of PMCH in all three countries of interest over the proposed experiment region: Eastern China, South Korea and Japan. Detailed model runs were made for all cases with grades of 'good' or 'High' and are indicated in green. Dates of Low qualitative probability are indicated in Blue.

Table 2. March 2007 Monthly Summary of release time qualitative grade (31 days):

Grade	High	Good	Low	Poor	Bad
Occurrences	1	3	15	13	30

Table 3. 24-hour average air concentrations in April 2007 for 1 kg normalized 0000 and 1200 UTC screening release times.

Date and Source Time (UTC)	Case Grade[1]	All China (fL/L)	China three preferred cities (fL/L)	All Japan (fL/L)	Japan seven preferred cities (fL/L)	South Korea (fL/L)
1 Apr 0000	Bad	1.20E-01	-	-	-	-
1 Apr 1200	Bad	6.26E-02	4.34E-03	-	-	-
2 Apr 0000	Low	2.08E-02	2.15E-02	2.34E-03	3.11E-03	1.99E-02
2 Apr 1200	Poor	4.92E-03	8.78E-03	1.62E-04	2.07E-04	2.12E-03
3 Apr 0000	Poor	7.53E-03	1.39E-02	1.40E-03	1.25E-03	4.30E-03
3 Apr 1200	Poor	3.57E-03	5.93E-03	6.51E-04	9.11E-04	8.16E-04
4 Apr 0000	Low	2.76E-02	4.59E-02	1.95E-03	2.07E-03	5.88E-03
4 Apr 1200	Bad	2.55E-02	1.10E-03	9.00E-04	4.33E-04	-
5 Apr 0000	Poor	1.57E-02	1.29E-03	7.62E-04	6.52E-04	1.71E-04
5 Apr 1200	Bad	1.25E-03	-	1.34E-03	-	-
6 Apr 0000	Poor	2.74E-03	1.05E-03	1.05E-03	1.38E-04	3.43E-05
6 Apr 1200	Poor	2.35E-02	1.52E-02	3.28E-04	3.28E-04	1.00E-03
7 Apr 0000	Poor	1.49E-02	1.42E-02	4.79E-04	5.40E-04	1.72E-03
7 Apr 1200	Poor	1.41E-04	1.15E-04	7.76E-04	7.76E-04	3.28E-03
8 Apr 0000	Poor	2.25E-03	2.75E-03	6.48E-04	7.34E-04	2.70E-03
8 Apr 1200	Poor	3.56E-03	1.02E-03	4.32E-04	4.81E-04	1.10E-04
9 Apr 0000	Low	1.17E-02	6.42E-04	2.43E-03	2.89E-03	1.42E-03
9 Apr 1200	Poor	1.78e-03	7.35E-04	3.36E-04	3.80E-04	2.79E-04
10 Apr 0000	Poor	2.64E-03	2.78E-03	1.72E-04	1.66E-04	9.31E-04
10 Apr 1200	Poor	9.89E-03	6.58E-03	7.02E-04	6.51E-04	3.37E-03
11 Apr 0000	Poor	6.43E-03	7.67E-04	9.94E-04	8.51E-04	6.14E-04
11 Apr 1200	Poor	3.30E-02	3.28E-04	7.70E-04	2.86E-04	1.07E-03
12 Apr 0000	Low	3.20E-03	4.15E-03	3.93E-03	2.93E-03	3.24E-03
12 Apr 1200	Low	6.58E-03	1.28E-02	2.93E-03	3.17E-03	7.17E-04
13 Apr 0000	Low	1.34E-03	8.77E-04	6.77E-03	7.51E-03	3.31E-04
13 Apr 1200	Bad	2.61E-03	1.43E-03	1.32E-03	1.06E-04	-
14 Apr 0000	Bad	2.08E-04	3.51E-04	2.12E-04	-	-
14 Apr 1200	Poor	1.38E-02	1.47E-02	5.04E-03	1.45E-04	1.01E-03
15 Apr 0000	Bad	8.49E-03	3.86E-03	1.72E-02	-	2.25E-04
15 Apr 1200	Bad	2.58E-02	2.09E-02	2.86E-05	-	1.23E-03
16 Apr 0000	Bad	2.45E-02	2.64E-02	1.83E-03	-	2.65E-03
16 Apr 1200	Bad	3.52E-02	6.77E-03	6.98E-04	-	1.43E-03
17 Apr 0000	Bad	4.22E-03	6.57E-03	1.99E-03	-	7.07E-04
17 Apr 1200	Bad	5.88E-02	1.76E-01	2.69E-04	-	-
18 Apr 0000	Poor	5.77E-03	1.04E-02	1.39E-04	1.80E-04	2.45E-04
18 Apr 1200	Poor	3.62E-03	6.43E-03	6.00E-04	6.10E-04	1.68E-03

Table 3 (continued). 24-hour average air concentrations in April 2007 for all regions of interest for both 0000 and 1200 UTC screening release times.

Date and Source Time (UTC)	Case Grade[1]	All China (fL/L)	China three preferred cities (fL/L)	All Japan (fL/L)	Japan seven preferred cities (fL/L)	South Korea (fL/L)
19 Apr 0000	Poor	8.60E-04	2.63E-03	6.53E-03	7.07E-05	1.65E-04
19 Apr 1200	Bad	4.54E-02	-	-	-	-
20 Apr 0000	Poor	1.50E-03	1.66E-04	1.81E-05	1.81E-05	4.71E-05
20 Apr 1200	Poor	3.53E-02	7.03E-04	2.49E-04	2.43E-04	1.68E-03
21 Apr 0000	Poor	4.45E-03	3.61E-03	1.83E-03	2.05E-03	2.60E-03
21 Apr 1200	Bad	9.96E-04	-	2.65E-05	2.65E-05	1.28E-04
22 Apr 0000	Bad	2.85E-03	-	3.61E-04	3.65E-04	6.49E-04
22 Apr 1200	Good	9.43E-02	2.46E-03	1.72E-02	1.96E-02	3.30E-02
23 Apr 0000	High	5.29E-02	8.55E-02	6.16E-02	9.44E-02	1.00E-01
23 Apr 1200	High	9.54E-02	2.53E-01	8.46E-02	9.63E-02	8.13E-02
24 Apr 0000	High	5.17E-02	1.04E-01	4.53E-02	5.78E-02	7.48E-02
24 Apr 1200	Good	2.39E-02	4.57E-02	3.06E-02	3.92E-02	5.13E-02
25 Apr 0000	Poor	1.98E-02	2.08E-02	1.13E-03	6.75E-04	1.01E-03
25 Apr 1200	Poor	5.60E-03	5.22E-03	6.42E-04	2.98E-04	8.88E-05
26 Apr 0000	Poor	8.34E-03	1.33E-02	1.09E-03	7.16E-04	2.57E-03
26 Apr 1200	Poor	6.54E-03	9.80E-03	1.36E-03	5.30E-04	1.85E-03
27 Apr 0000	Low	1.60E-02	2.38E-02	1.23E-03	1.13E-03	2.99E-03
27 Apr 1200	Low	1.11E-02	1.66E-02	1.27E-03	1.36E-03	3.79E-03
28 Apr 0000	Poor	4.22E-02	4.22E-02	2.54E-04	1.16E-04	1.84E-04
28 Apr 1200	Poor	2.79E-02	2.79E-02	1.43E-04	2.03E-03	2.13E-03
29 Apr 0000	Low	3.80E-03	6.67E-03	7.31E-03	9.24E-03	2.02E-03
29 Apr 1200	Low	2.69E-02	6.22E-02	7.78E-03	7.64E-03	2.31E-02
30 Apr 0000	Low	1.66E-02	3.14E-03	3.07E-03	3.07E-03	1.86E-02
30 Apr 1200	Low	2.60E-02	6.03E-02	5.48E-03	3.86E-03	3.84E-03

Notes:

1. Cases have been graded from Bad to High in a qualitative manner to estimate the chance that the release for that date in time could produce detectable levels of PMCH in all three countries of interest over the proposed experiment region: Eastern China, South Korea and Japan. Detailed model runs were made for all cases with grades of 'good' or 'High' and are indicated in green. Dates of Low qualitative probability are indicated in Blue.

Table 4. April 2007 Monthly Summary of release time qualitative grade (30 days):

Grade	High	Good	Low	Poor	Bad
Occurrences	3	2	12	28	15

Table 5. 24-hour average air concentrations in May 2007 for 1 kg normalized 0000 and 1200 UTC screening release times.

Date and Source Time (UTC)	Case Grade[1]	All China (fL/L)	China three preferred cities (fL/L)	All Japan (fL/L)	Japan seven preferred cities (fL/L)	South Korea (fL/L)
1 May 0000	Poor	2.71E-02	4.06E-02	1.85E-03	2.13E-04	6.53E-04
1 May 1200	Poor	1.50E-02	2.42E-02	4.94E-03	1.91E-03	7.56E-03
2 May 0000	Poor	9.11E-02	7.25E-04	8.47E-03	2.38E-04	1.03E-04
2 May 1200	Poor	7.29E-02	6.09E-03	4.52E-03	1.01E-04	3.92E-05
3 May 0000	Poor	4.75E-03	1.22E-03	1.90E-03	3.25E-04	1.40E-03
3 May 1200	Poor	8.07E-03	6.95E-05	1.01E-03	3.83E-04	9.06E-04
4 May 0000	Poor	9.93E-04	5.83E-04	2.26E-04	2.26E-04	6.63E-04
4 May 1200	Poor	3.13E-02	1.02E-03	7.37E-04	8.31E-04	2.17E-02
5 May 0000	Poor	2.10E-03	2.47E-03	6.01E-04	5.19E-04	2.65E-03
5 May 1200	Poor	1.65E-03	6.97E-04	9.80E-05	4.90E-05	1.48E-04
6 May 0000	Poor	4.66E-03	7.05E-03	2.74E-04	3.04E-04	2.74E-04
6 May 1200	Poor	5.18E-04	2.60E-04	3.11E-05	2.34E-05	1.52E-04
7 May 0000	Poor	8.18E-03	8.59E-03	1.31E-03	1.10E-03	2.15E-03
7 May 1200	Bad	2.26E-04	-	4.28E-04	-	-
8 May 0000	Low	1.89E-02	1.44E-02	2.26E-03	2.10E-03	3.89E-03
8 May 1200	Poor	2.41E-03	4.26E-03	3.32E-04	2.22E-04	7.08E-04
9 May 0000	Bad	-	-	-	-	-
9 May 1200	Bad	-	-	-	-	-
10 May 0000	Low	1.20E-02	1.57E-02	8.72E-03	1.15E-02	1.61E-02
10 May 1200	Good	5.76E-02	8.00E-02	3.18E-02	4.67E-02	8.91E-02
11 May 0000	Good	4.41E-02	9.52E-03	1.66E-02	2.42E-02	6.98E-02
11 May 1200	Low	1.13E-01	1.70E-01	8.27E-03	1.20E-02	3.12E-02
12 May 0000	Low	4.85E-02	4.85E-02	5.39E-03	4.83E-03	1.59E-02
12 May 1200	Poor	1.19E-01	1.19E-01	3.70E-03	3.39E-03	1.15E-02
13 May 0000	Poor	3.27E-04	3.27E-04	2.09E-03	2.73E-03	5.48E-03
13 May 1200	Poor	3.35E-03	3.35E-03	1.99E-03	2.51E-03	1.25E-03
14 May 0000	Poor	2.61E-04	2.61E-04	5.68E-04	7.20E-04	2.64E-04
14 May 1200	Low	2.42E-02	2.42E-02	1.00E-02	1.54E-02	5.07E-03
15 May 0000	Poor	3.13E-03	3.13E-03	2.52E-04	2.52E-04	5.80E-04
15 May 1200	Poor	3.28E-04	3.39E-05	1.90E-03	1.77E-03	2.79E-03
16 May 0000	Poor	1.54E-02	3.08E-02	1.72E-03	2.21E-03	7.17E-03
16 May 1200	Poor	3.66E-03	5.46E-04	5.67E-04	6.57E-04	2.27E-04
17 May 0000	Bad	2.34E-02	1.56E-03	5.90E-06	-	2.47E-05
17 May 1200	Bad	1.56E-02	1.62E-02	4.95E-04	-	7.39E-04
18 May 0000	Poor	1.23E-02	1.22E-02	1.51E-03	1.56E-03	2.26E-03
18 May 1200	Bad	4.00E-03	4.00E-03	4.79E-04	-	-

Table 5 (continued). 24-hour average air concentrations in May 2007 for 1 kg normalized 0000 and 1200 UTC screening release times.

Date and Source Time (UTC)	Case Grade[1]	All China (fL/L)	China three preferred cities (fL/L)	All Japan (fL/L)	Japan seven preferred cities (fL/L)	South Korea (fL/L)
19 May 0000	Bad	3.24E-03	2.17E-03	7.92E-04	-	-
19 May 1200	Bad	3.28E-03	-	-	-	3.69E-05
20 May 0000	Poor	1.11E-03	1.01E-03	2.33E-04	2.33E-04	3.35E-04
20 May 1200	Poor	9.20E-04	1.21E-03	4.49E-04	5.03E-04	9.84E-04
21 May 0000	Poor	4.40E-03	1.12E-04	1.98E-04	1.98E-04	2.79E-04
21 May 1200	Poor	6.03E-03	1.63E-03	6.74E-04	7.64E-04	1.03E-03
22 May 0000	Poor	1.86E-02	8.88E-03	1.16E-03	1.26E-03	1.02E-03
22 May 1200	Poor	1.16E-02	6.32E-03	1.13E-03	1.13E-03	1.87E-03
23 May 0000	Poor	7.49E-03	5.59E-03	5.19E-04	5.19E-04	1.12E-03
23 May 1200	Good	7.80E-02	3.23E-02	1.79E-02	1.79E-02	2.97E-02
24 May 0000	High	4.57E-02	7.90E-02	5.54E-02	7.10E-02	5.27E-02
24 May 1200	High	8.47E-02	1.59E-01	2.21E-02	2.58E-02	6.90E-02
25 May 0000	Poor	1.08E-02	1.93E-02	5.69E-04	7.75E-04	3.80E-03
25 May 1200	Poor	1.14E-01	2.20E-01	7.51E-04	7.87E-04	2.59E-03
26 May 0000	Poor	1.80E-02	1.25E-02	4.77E-04	2.79E-04	1.20E-03
26 May 1200	Bad	4.28E-02	1.90E-04	-	-	-
27 May 0000	Bad	2.07E-02	1.35E-04	-	-	-
27 May 1200	Bad	6.36E-03	5.45E-03	-	-	-
28 May 0000	Bad	2.16E-03	1.73E-03	2.24E-05	2.24E-05	-
28 May 1200	Bad	-	-	-	-	-
29 May 0000	Bad	-	-	-	-	-
29 May 1200	Bad	-	-	-	-	-

Notes:
1. Cases have been graded from Bad to High in a qualitative manner to estimate the chance that the release for that date in time could produce detectable levels of PMCH in all three countries of interest over the proposed experiment region: Eastern China, South Korea and Japan. Detailed model runs were made for all cases with grades of 'good' or 'High' and are indicated in green. Dates of Low qualitative probability are indicated in Blue.

Table 6. May 2007 Monthly Summary of release time qualitative grade (29 days):

Grade	High	Good	Low	Poor	Bad
Occurrences	2	3	5	33	15