Impacts of Highway Networks on the Ambient Ozone Concentrations in Southern Taiwan

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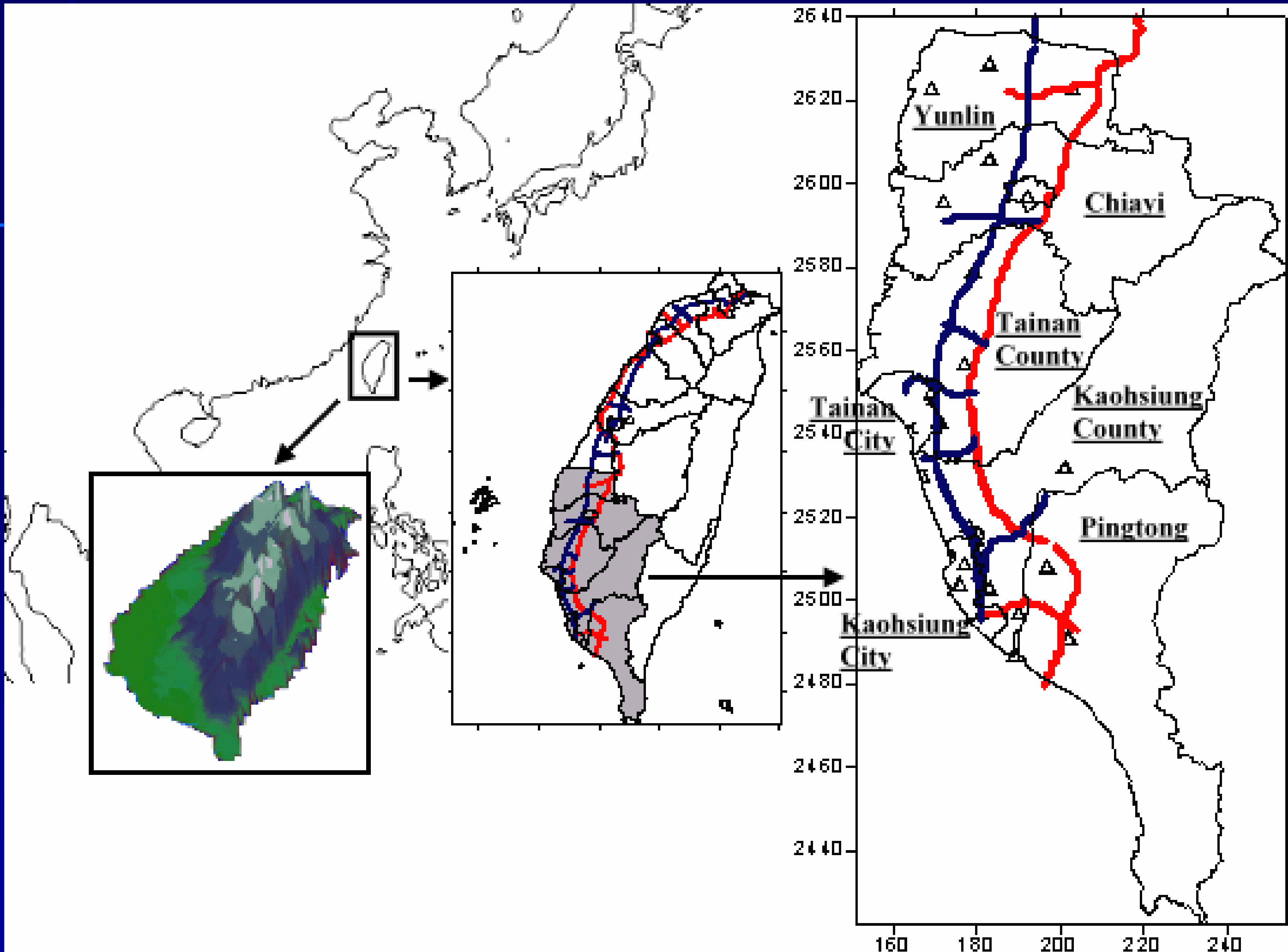
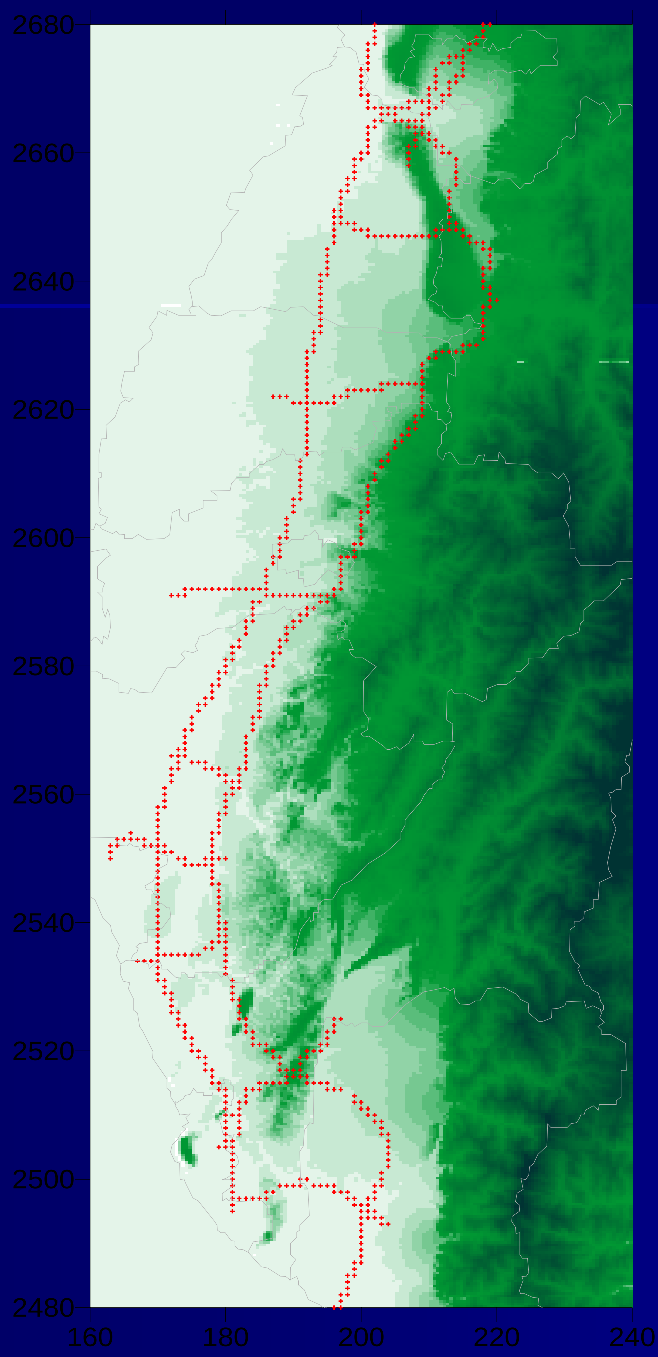
Introduction

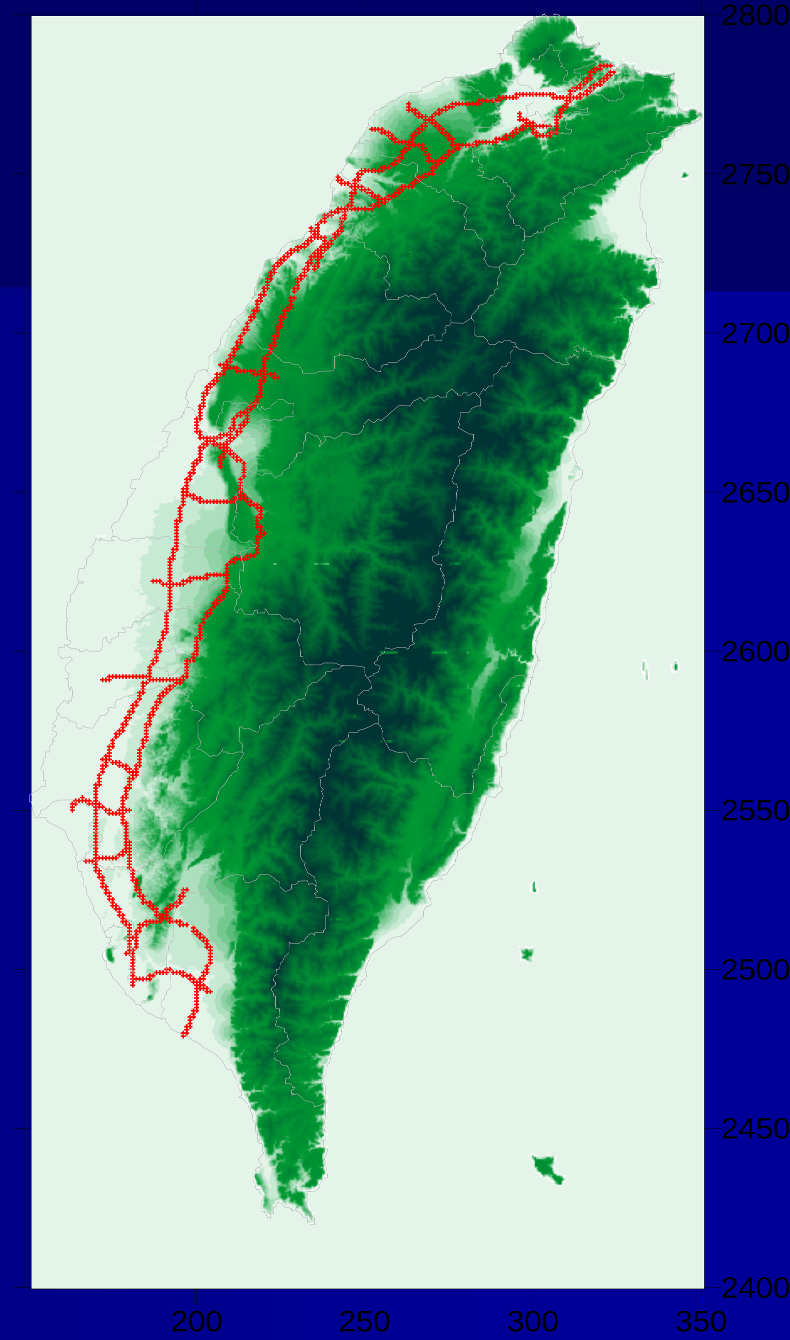
- The changes in the spatial distributions of NOx and NMHC caused by traffic patterns during weekend may affect the ozone concentrations in southern California (Chinkin et al, 2003; Gao et al., 2005; Jimenez et al., 2005).
- Reducing highway emissions may considerably change ozone levels downwind of the highway (Suppan and Schadler, 2004).
- Controlling the mobile source increased the potential effects for emissions from other sources on ozone concentrations (Tao et al., 2005).



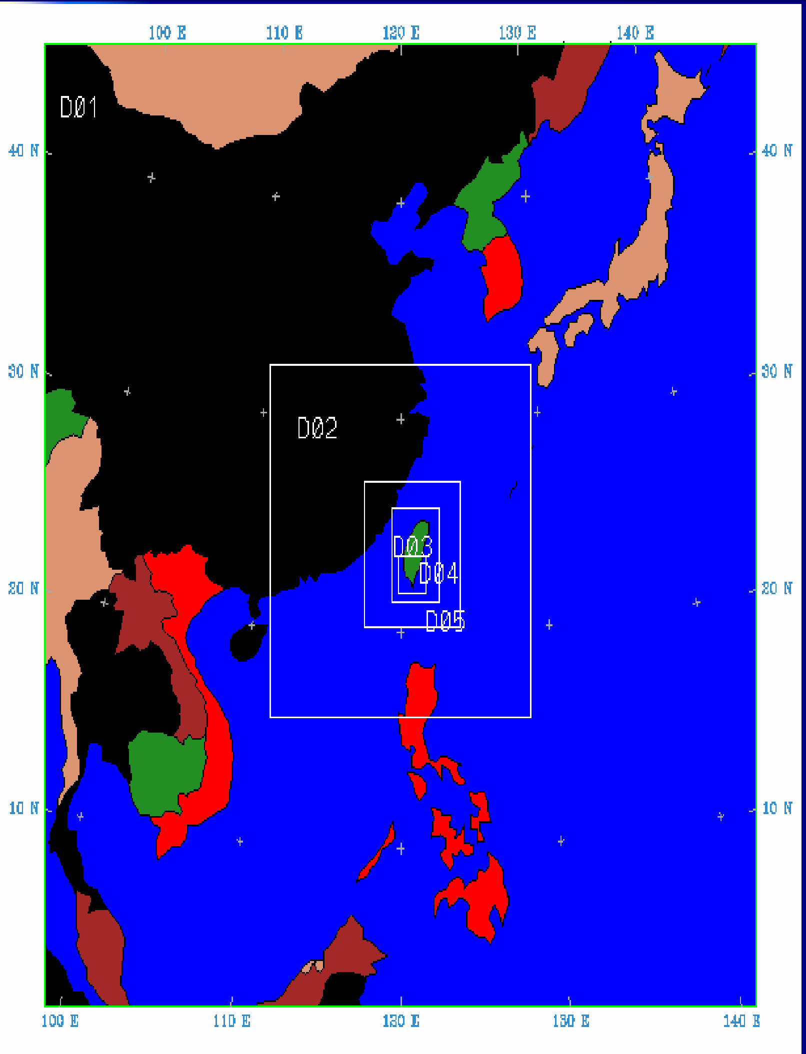
Yunlin
Chiayi
Tainan County
Tainan City
Kaohsiung County
Pingtong
Kaohsiung City
2640
2620
2600
2580
2560
2540
2520
2500
2480
2460
2440
160
180
200
220
240

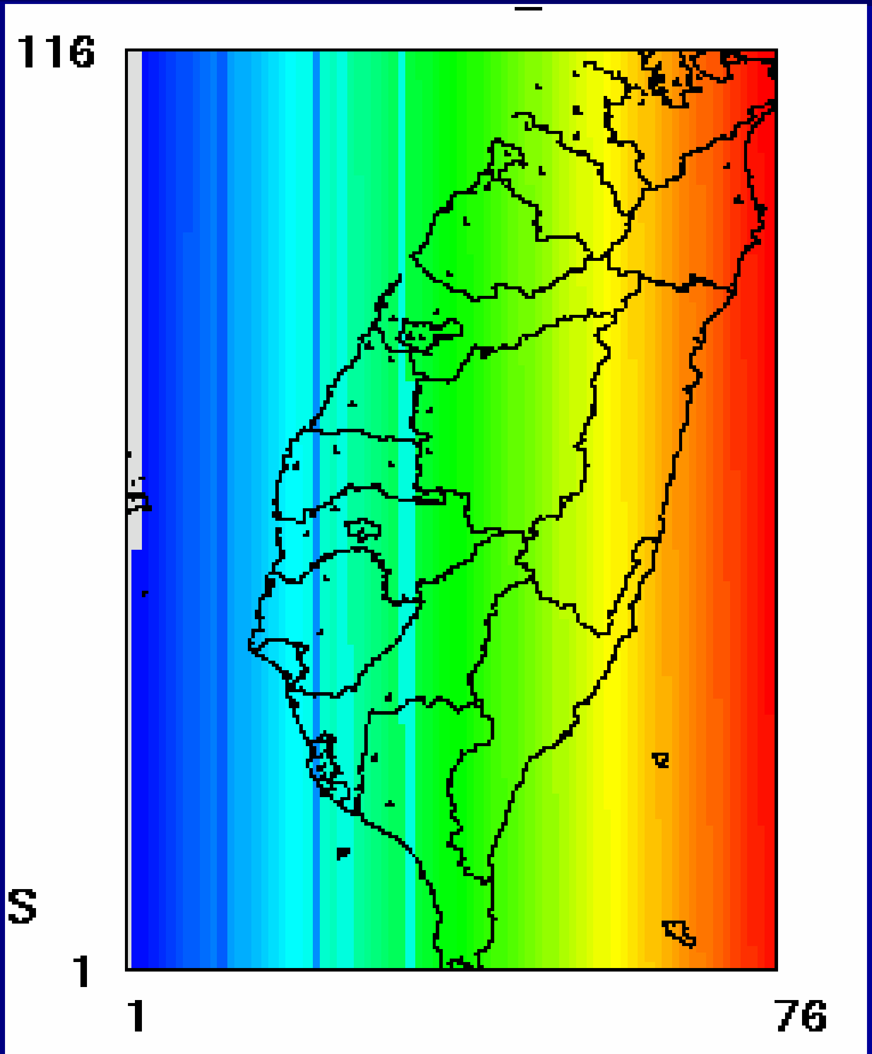
The grograhics and the hiway loctions





Simulation Domains





Sigma-layer

Layer	Sigma	實際大氣壓力（Pa）	全域高度（m）	代表高度（m）
15	0.000	10000	21146	17223
14	0.150	23500	13300	10688
13	0.350	41500	8077	6784
12	0.500	55000	5490	4794
11	0.600	64000	4099	3494
10	0.700	73000	2890	2616
9	0.750	77500	2341	2082
8	0.800	82000	1823	1577
7	0.850	86500	1332	1145
6	0.890	90100	957	777
5	0.930	93700	598	467
4	0.960	96400	337	252
3	0.980	98200	167	125
2	0.990	99100	83	62
1	0.995	99550	41	21
0	1.000	100000	0	

Air Pollutant Concentrations and Meteorological Conditions during Simulation Periods

Species	Number of site	14,Dec.	15,Dec.	16,Dec.	17,Dec.
O_3: average of hourly maximum(ppb)*	22	77	93	71	131
O_3: hourly maximum(ppb)	22	100	150	113	161
O_3: monitoring site of hourly maximum	22	Put z	Li nyuan	Chaochou	Zouying
Number of O_3 nonattainment site	22	0	2	0	19
NMHC (ppmC)	12	0.55	0.44	0.52	0.61
NO_2 (ppb)	22	30	25	30	32
NO (ppb)	22	12	6.1	8.7	11
PM10 (ug/m^3)	22	84	84	82	116
SO_2 (ppb)	22	5.6	6.2	6.9	6.9
Temperature (degree C)	22	18.7	20.3	21.5	22.1
Wind speed (m/s)*	20	1.2	1.5	1.5	1.1
Dominant wind direction during peak O_3	20	Northen West	Northen West	Northen West	West

Emissions of TSP, SOx, NOx, and NMHC from Anthropogenic Sources

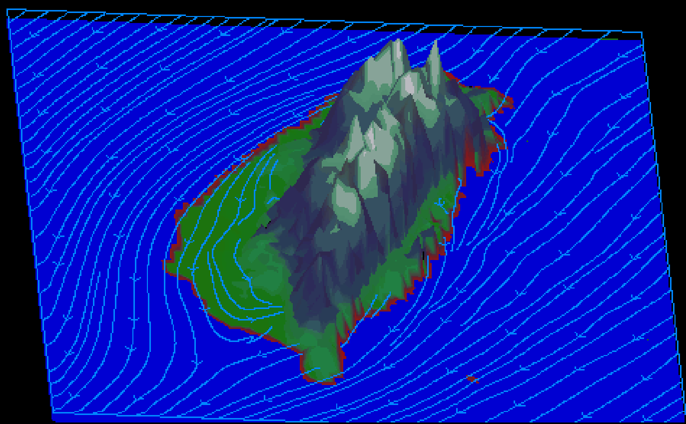
	TSP	SOx	NOx	NMHC
Point	170	226	361	273
Mobile	43	5	222	203
Area	587	16	15	556
Total	799	246	599	1032

Unit: KT/yr

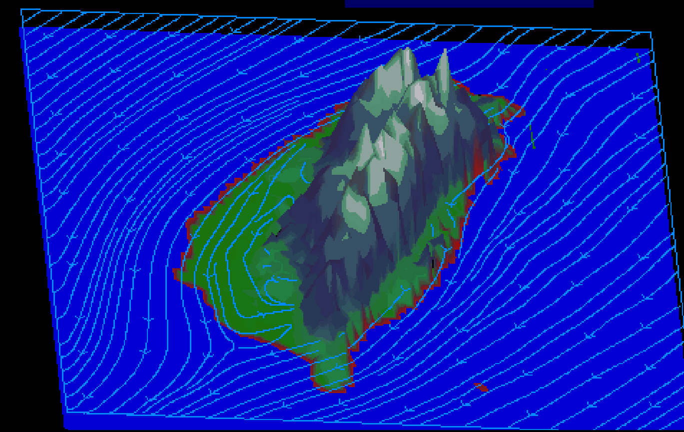
Contributions of Various Sources During Simulation Period

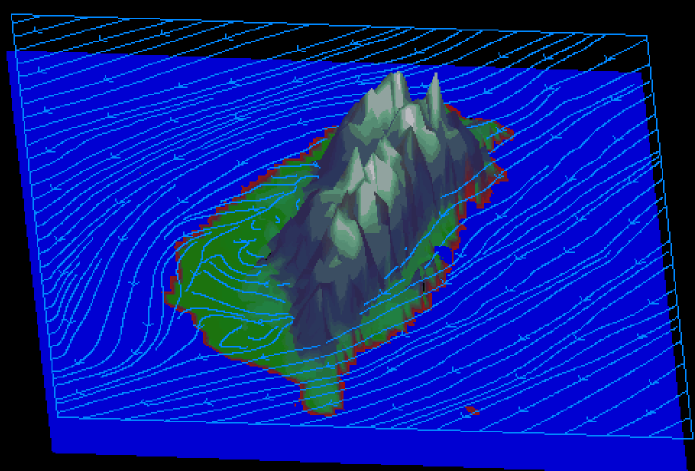
Sources	SOx	NOx	NMHC	CO
Point	91%	52%	10%	5.5%
Area	6.8%	3.0%	46%	17%
Mobile(Non-highway)	1.3%	30%	16%	69%
Mobile(1st highway)	0.5%	10%	1.1%	5.5%
Mobile(2nd highway)	0.2%	3.8%	0.4%	2.1%
Mobile(other highway)	0.0%	0.9%	0.1%	0.5%
Biogenic	-	-	26%	-

300 m

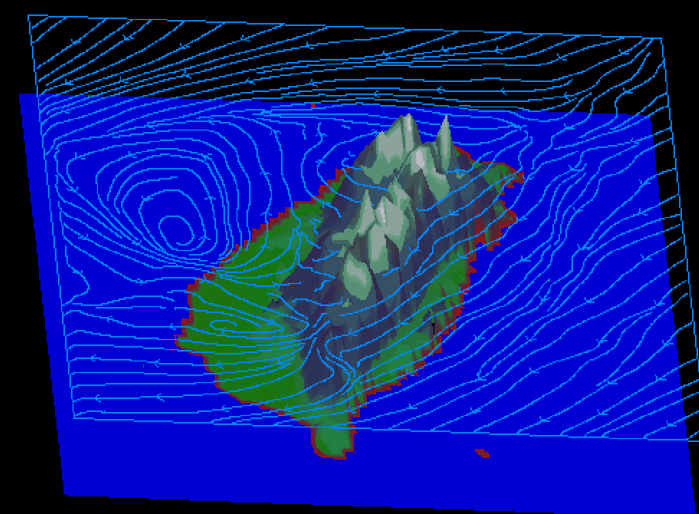


500 m



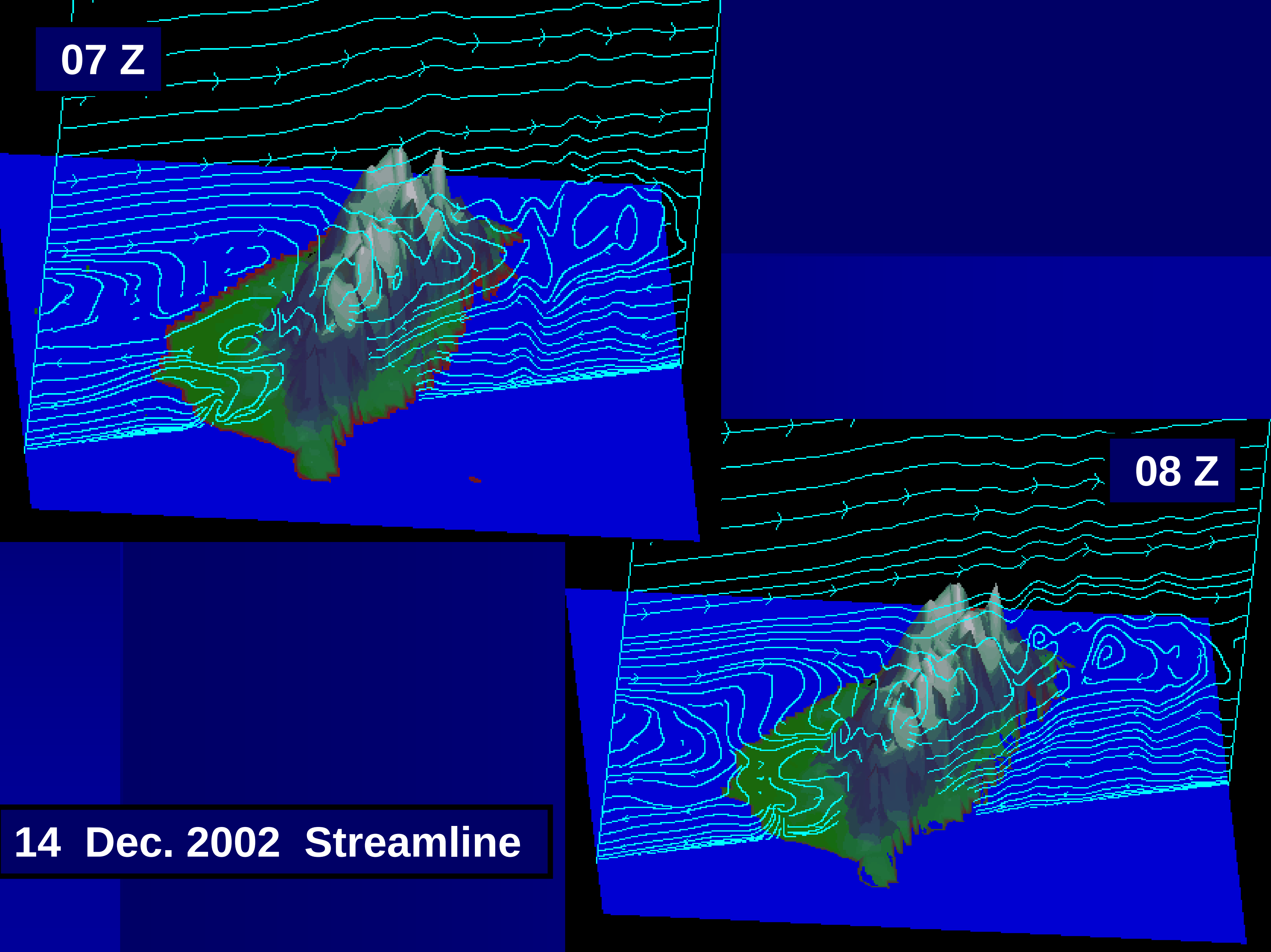


1000 m

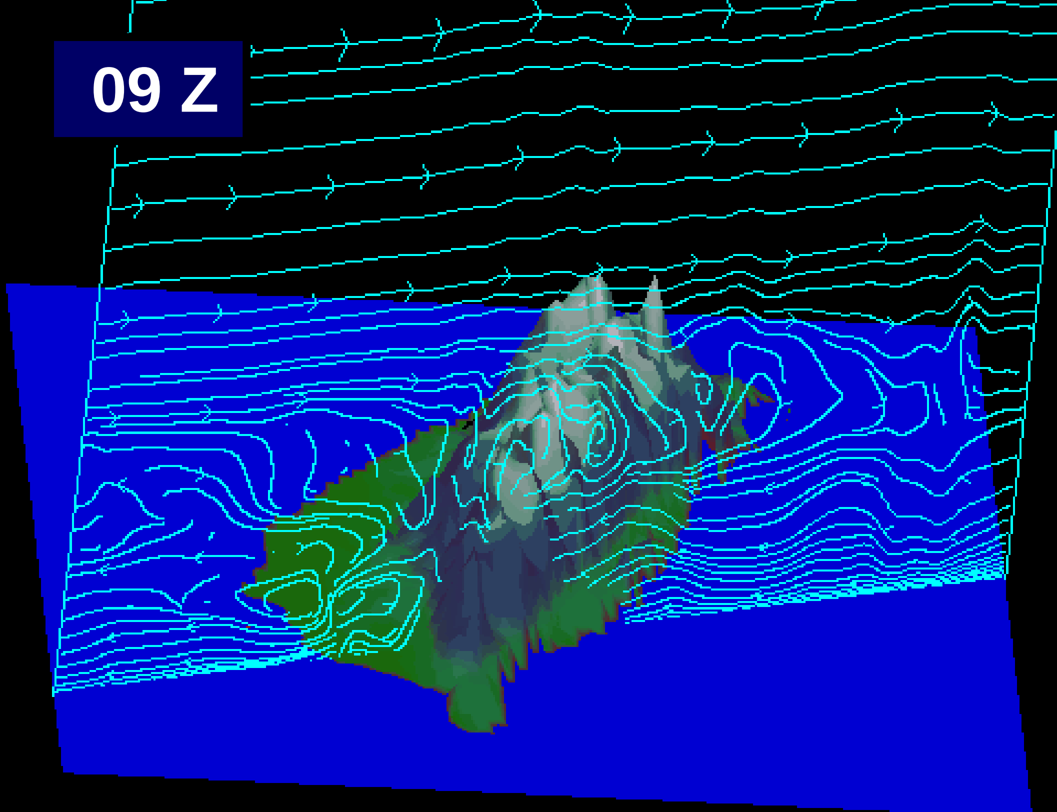


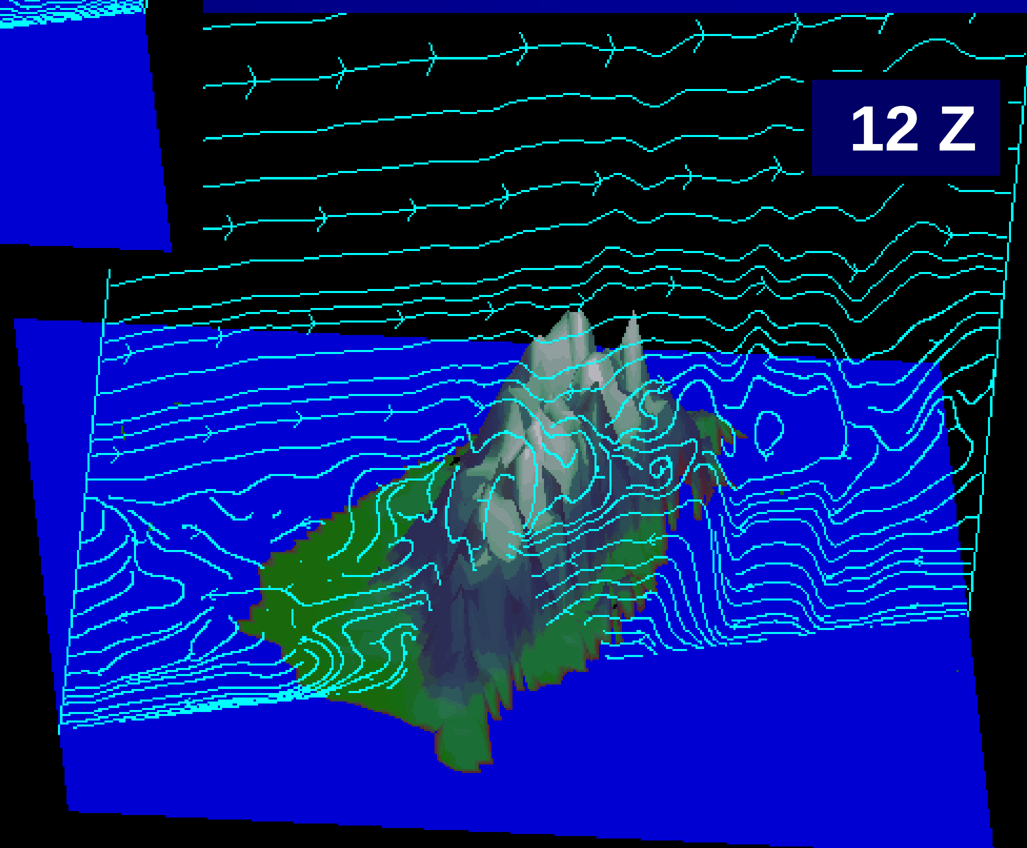
2000m

06Z 14 Dec. 2002 Streamline

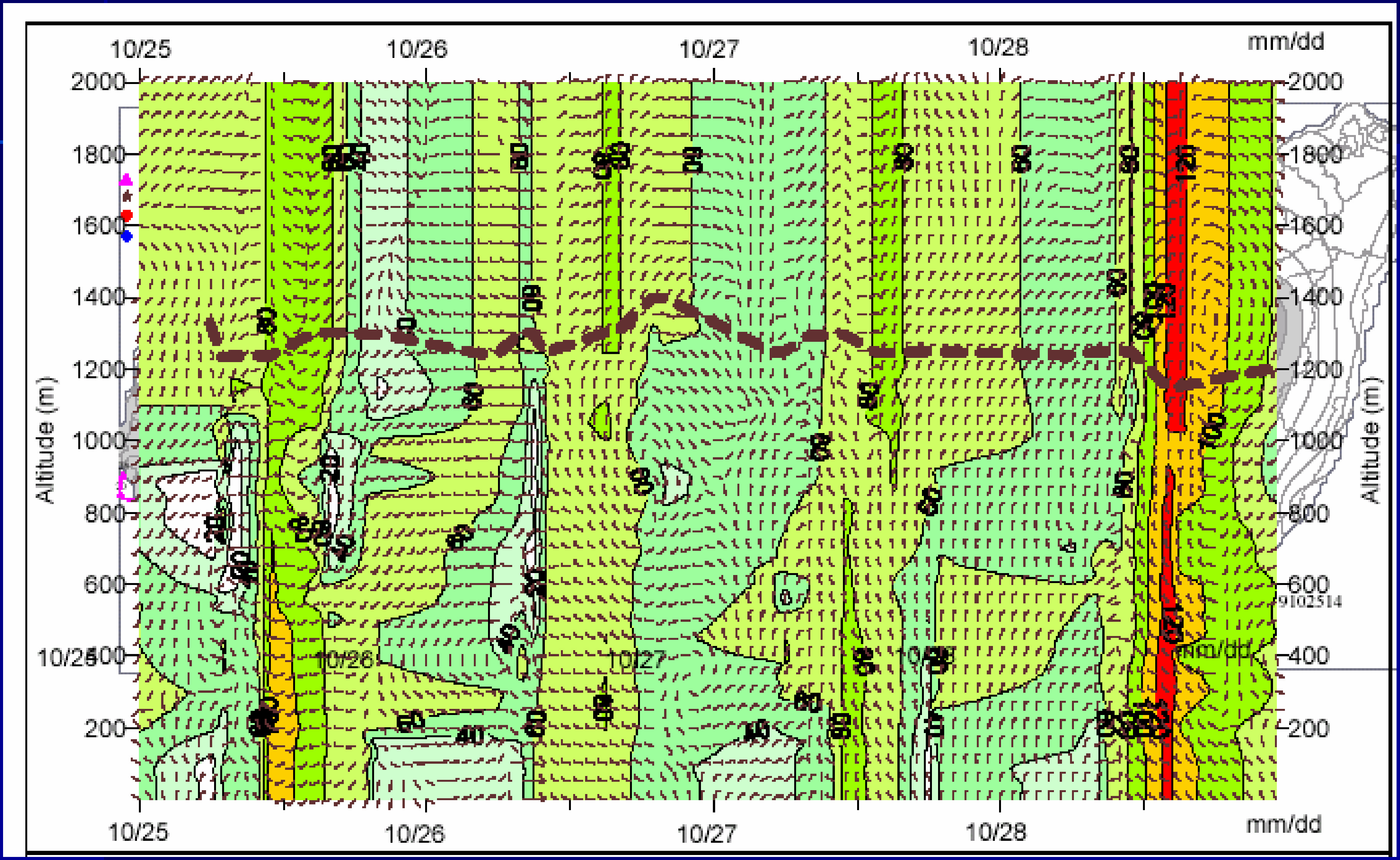


14 Dec. 2002 Streamline

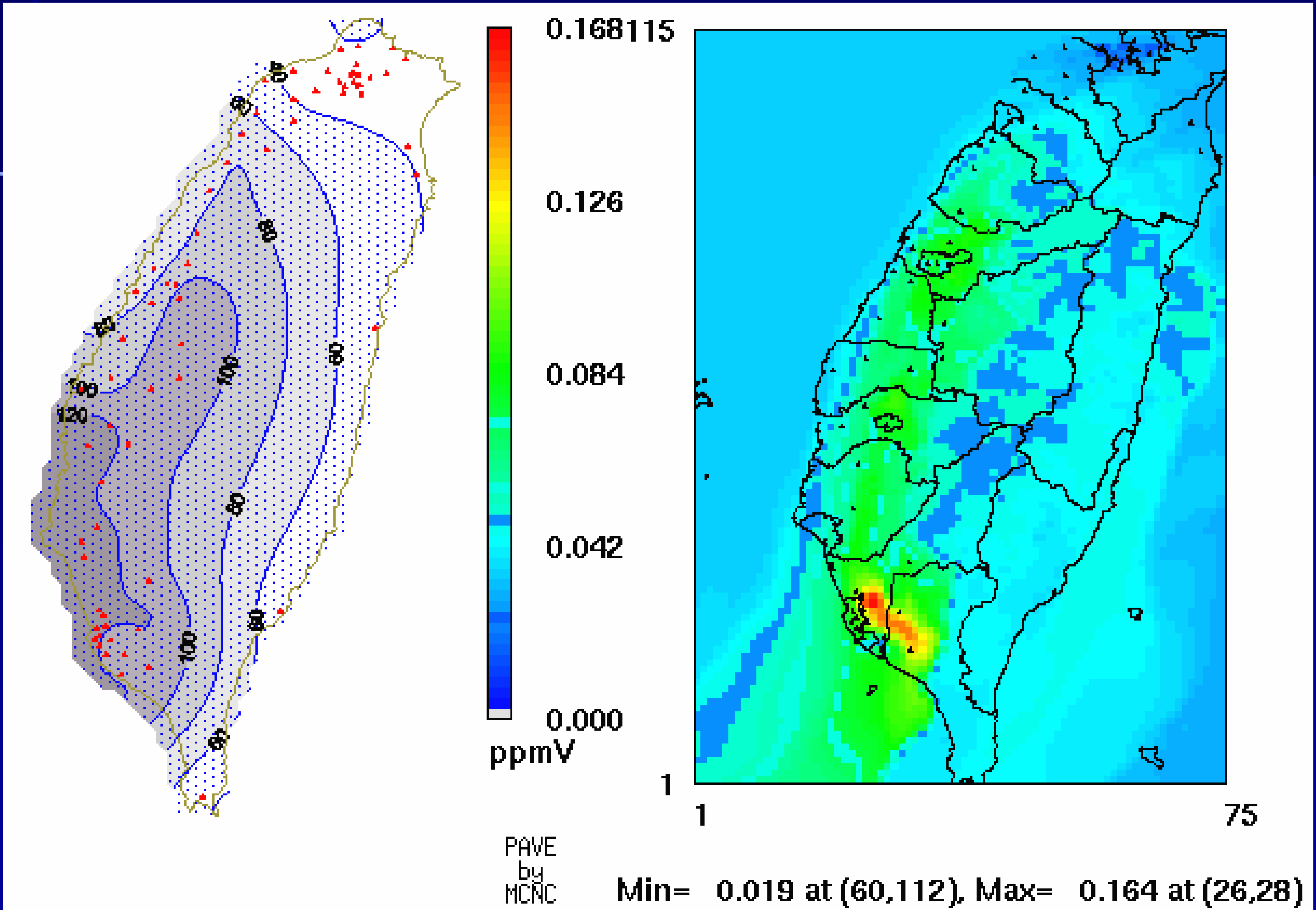




14 Dec. 2002 Streamline

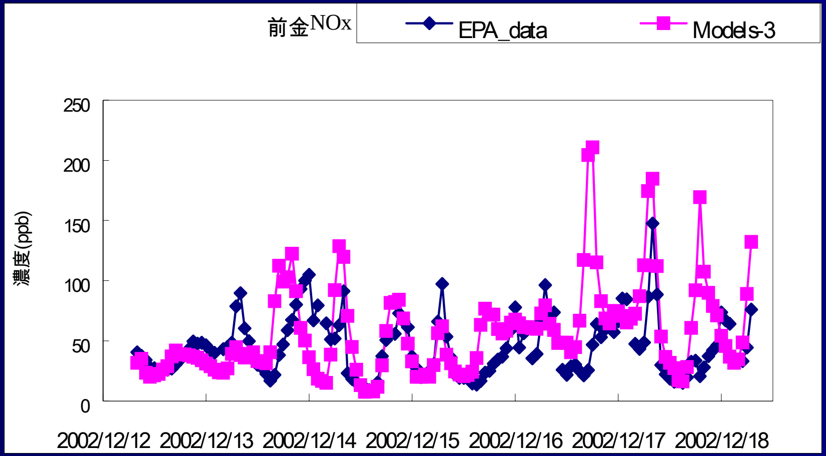


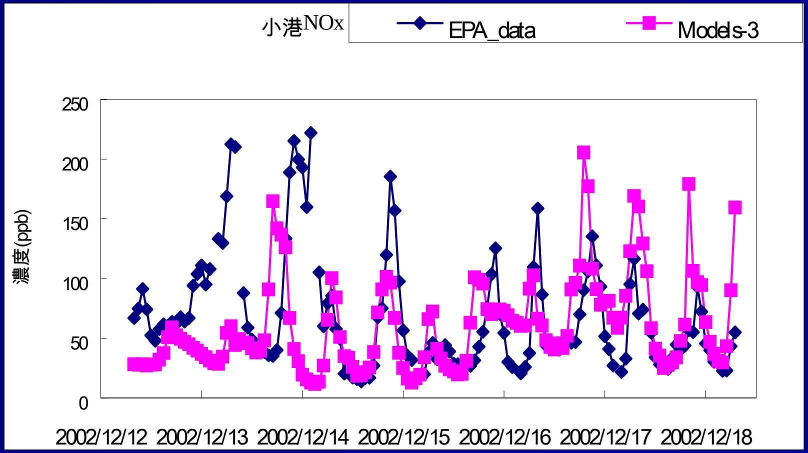
10/25
10/26
10/27
10/28
mm/dd
2000
1800
1600
1400
1200
1000
800
600
400
200
Altitude (m)

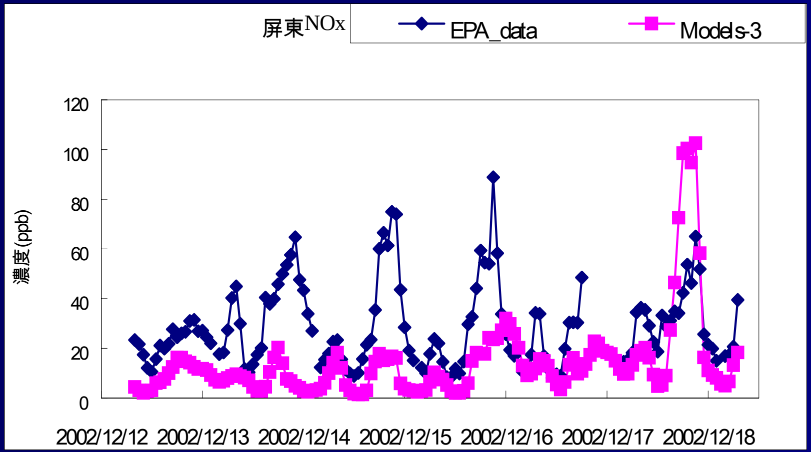


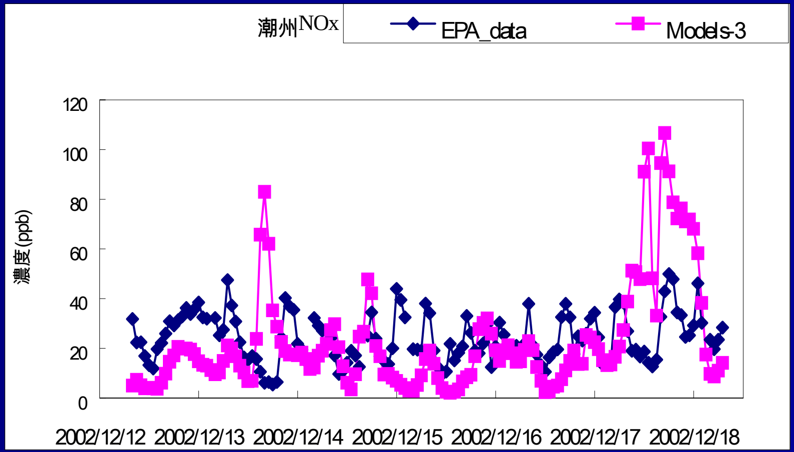
0.168115
0.126
0.084
0.042
0.000
ppmV
1
1
75
PAVE
by
MCNC
Min= 0.019 at (60,112), Max= 0.164 at (26,28)

Comparisons between simulated and observed NOx concentrations for temporal variations

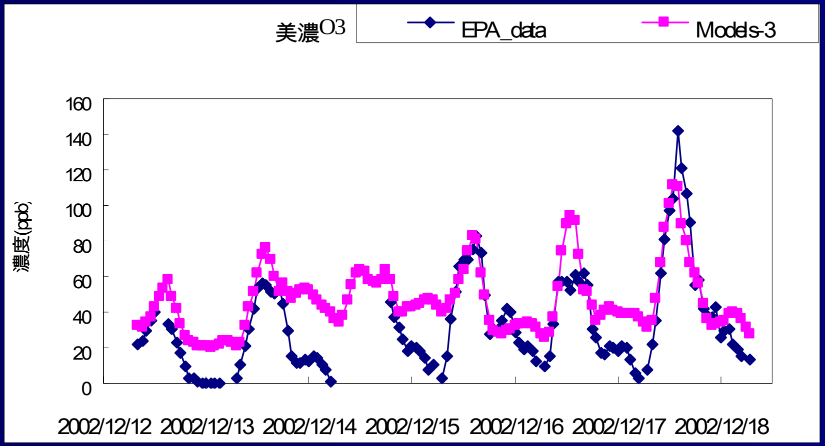


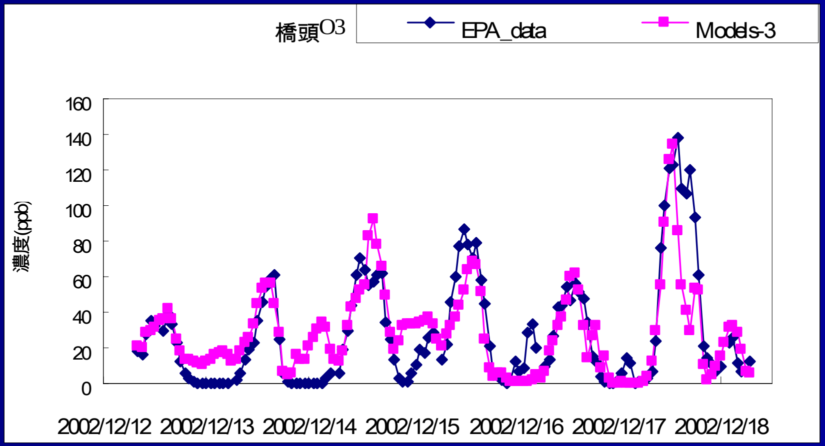


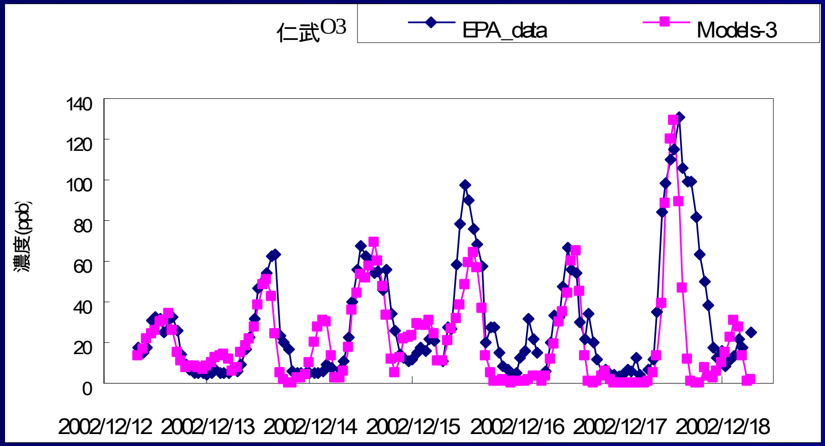


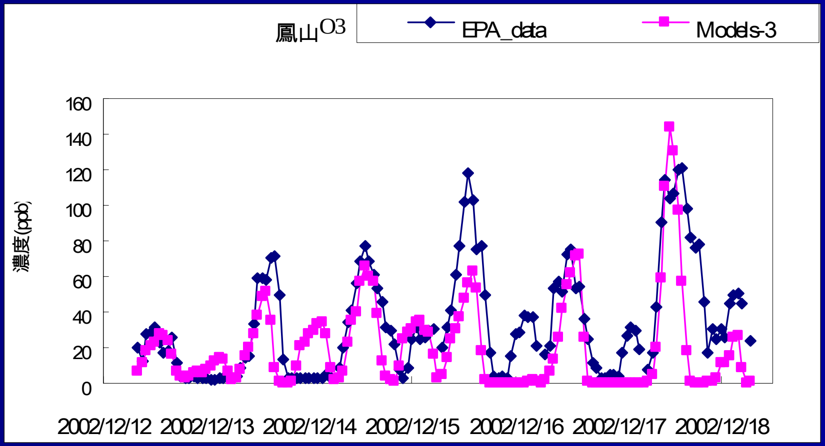


Comparisons between simulated and observed ozone concentrations for temporal variations

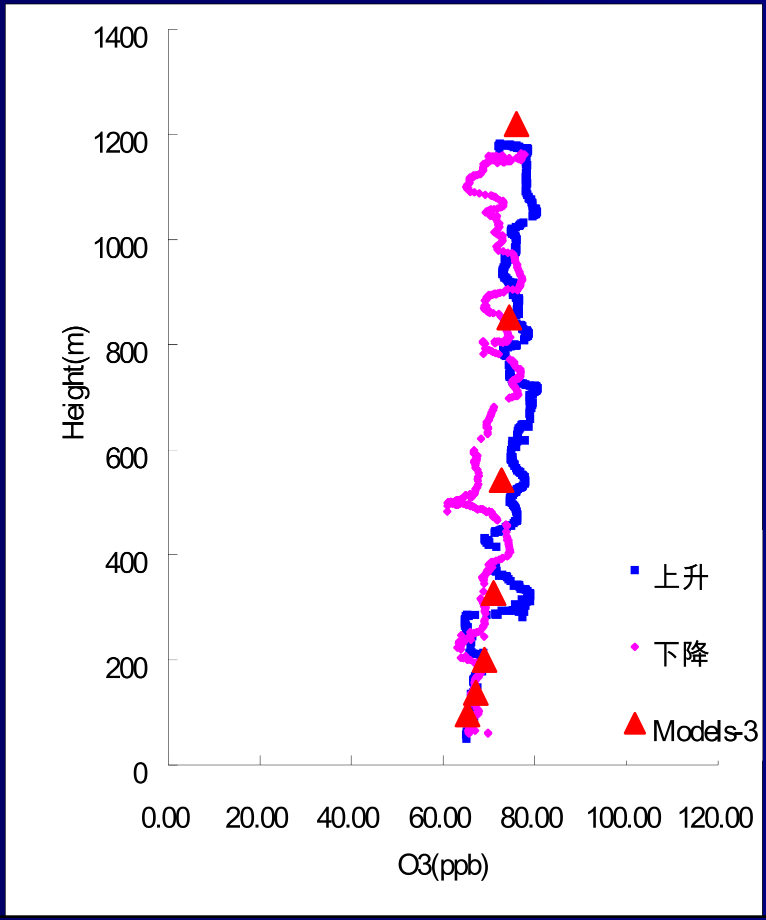




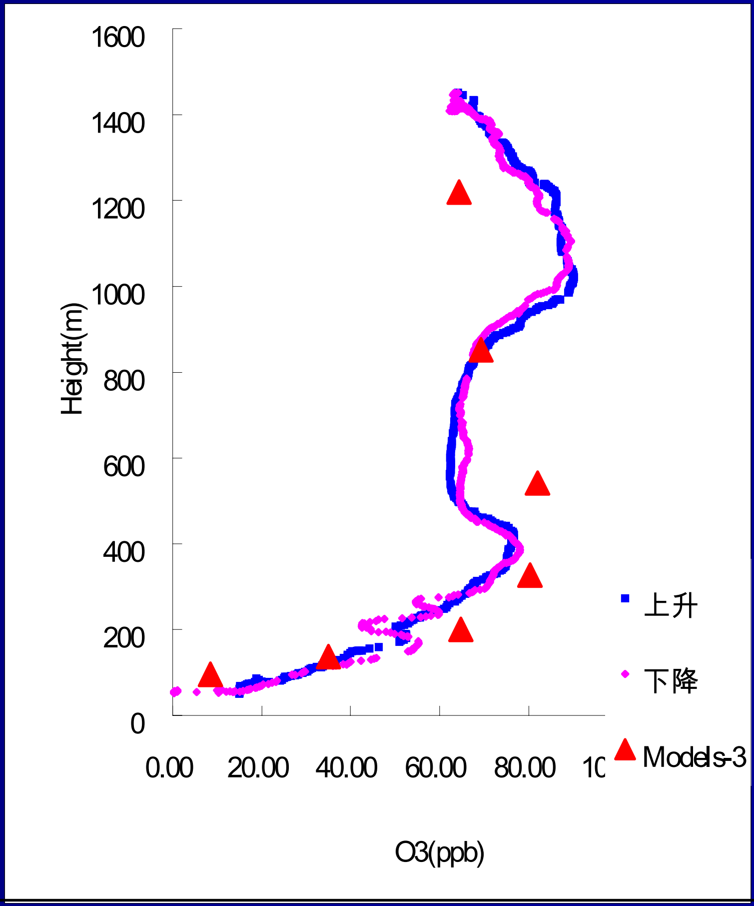




Comparisons between simulated and observed vertical profiles of ozone concentrations



繫流氣球時間：13：22～14：15



繫流氣球時間：19：22～20：21

	EPA goal	14-Dec	15-Dec	16-Dec	17-Dec
Observed peak(ppb)		100	150	113	161
Modeled peak(ppb)		114	83	95	155
UHPA*	< ±20%	-15%	45%	17%	3.9%
MNBT*	< ±20%	1%	28%	8%	32%
MNGE*	< 35%	15%	20%	22%	24%

Three cases

A: base case

B: emission from the 1st highway only

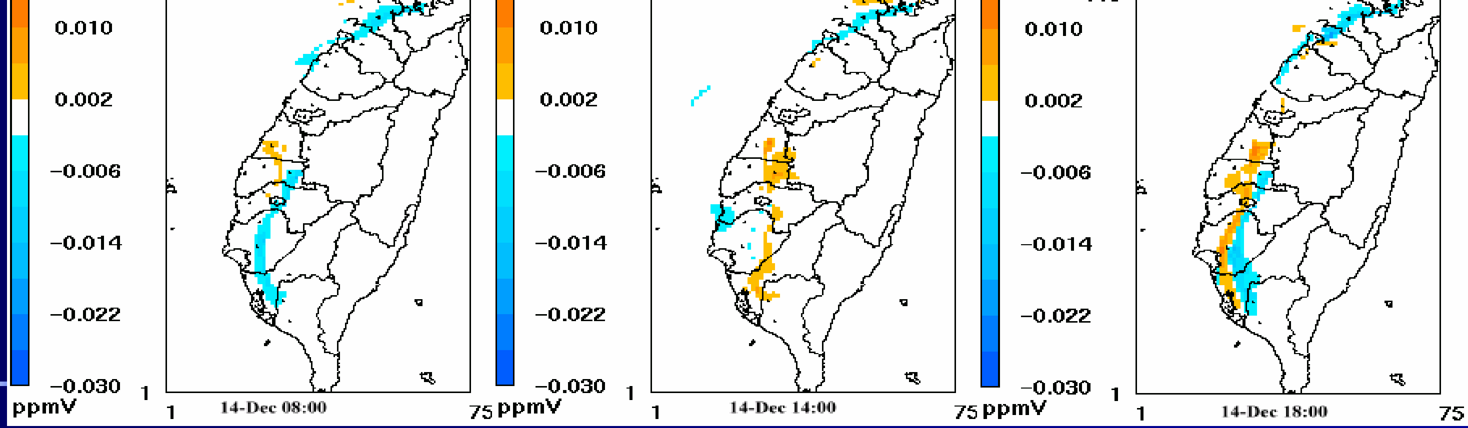
C: emission from the 2nd highway only

Two scenarios

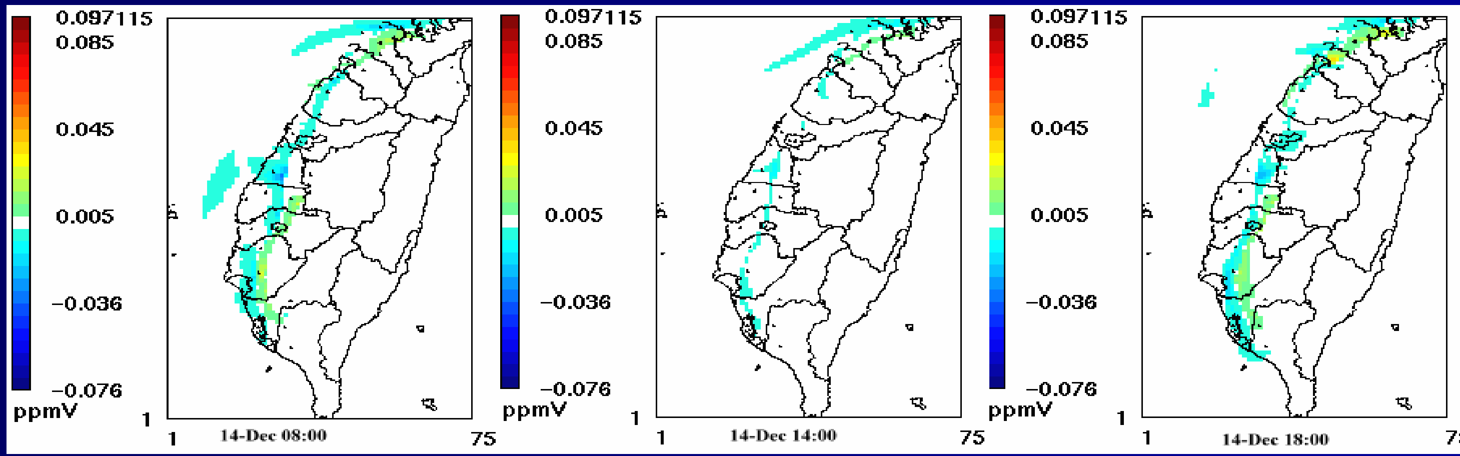
I: (A-B)

II: (C-B)

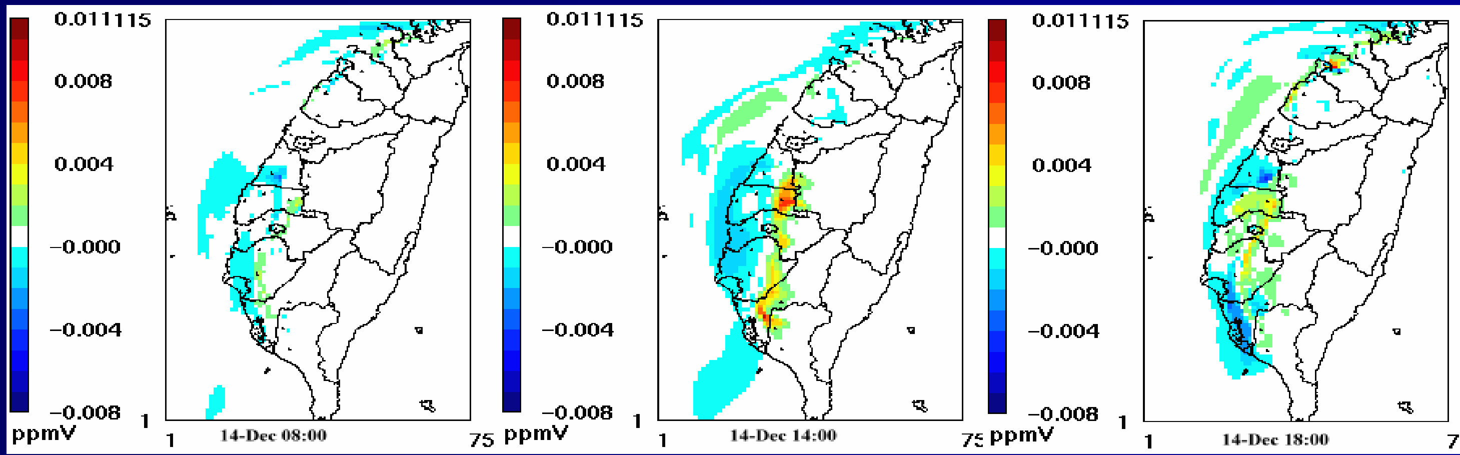
O3


0.010
0.002
−0.006
−0.014
−0.022
−0.030
ppmV
1
1
14-Dec 08:00
75
14-Dec 14:00
14-Dec 18:00

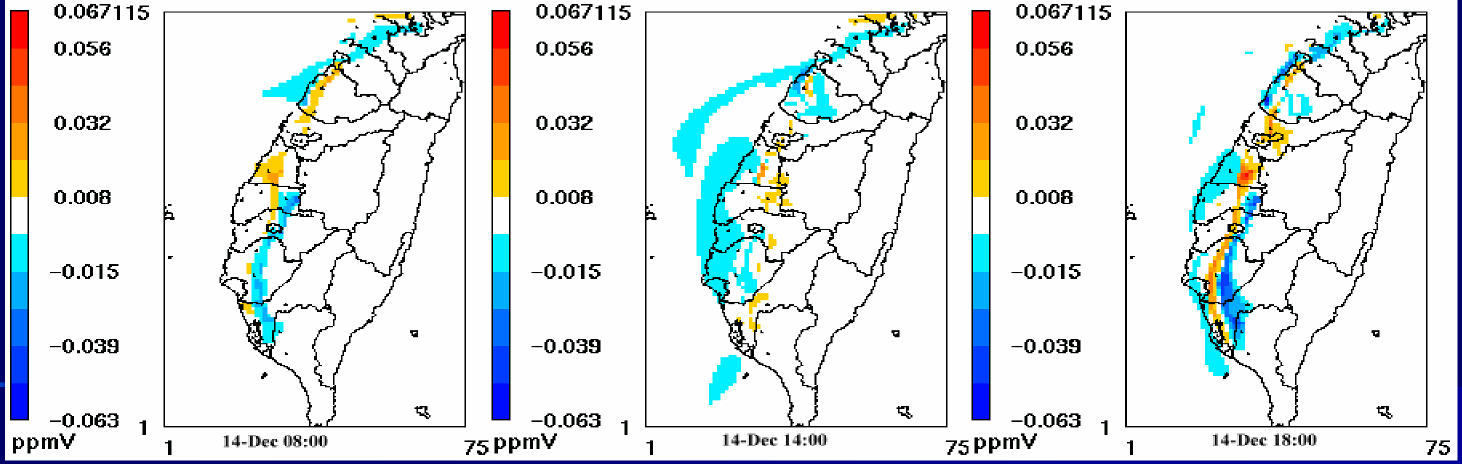
NOx


0.097115
0.085
0.045
0.005
−0.036
−0.076
ppmV
1
1
14-Dec 08:00
75
14-Dec 14:00
14-Dec 18:00

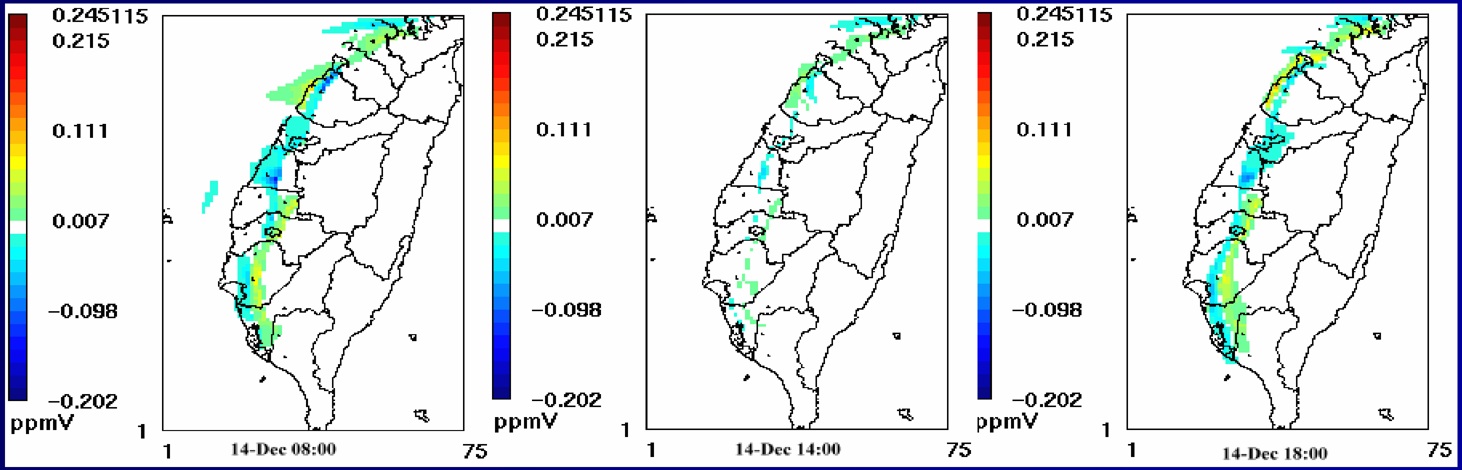
NO2+O3


0.011115
0.008
0.004
−0.000
−0.004
−0.008
ppmV
1
1
14-Dec 08:00
75
14-Dec 14:00
14-Dec 18:00

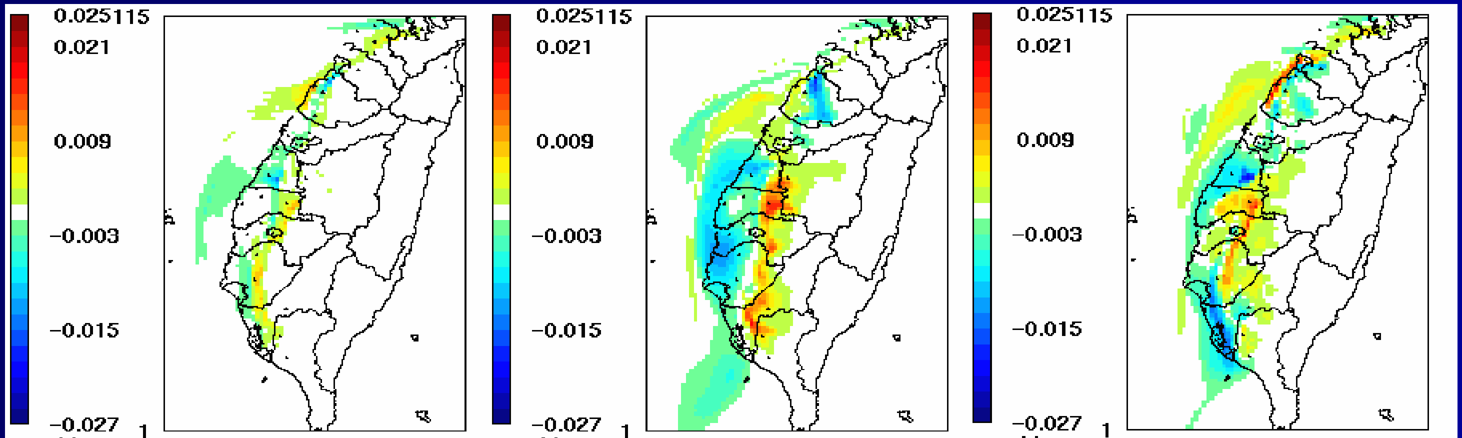
O3

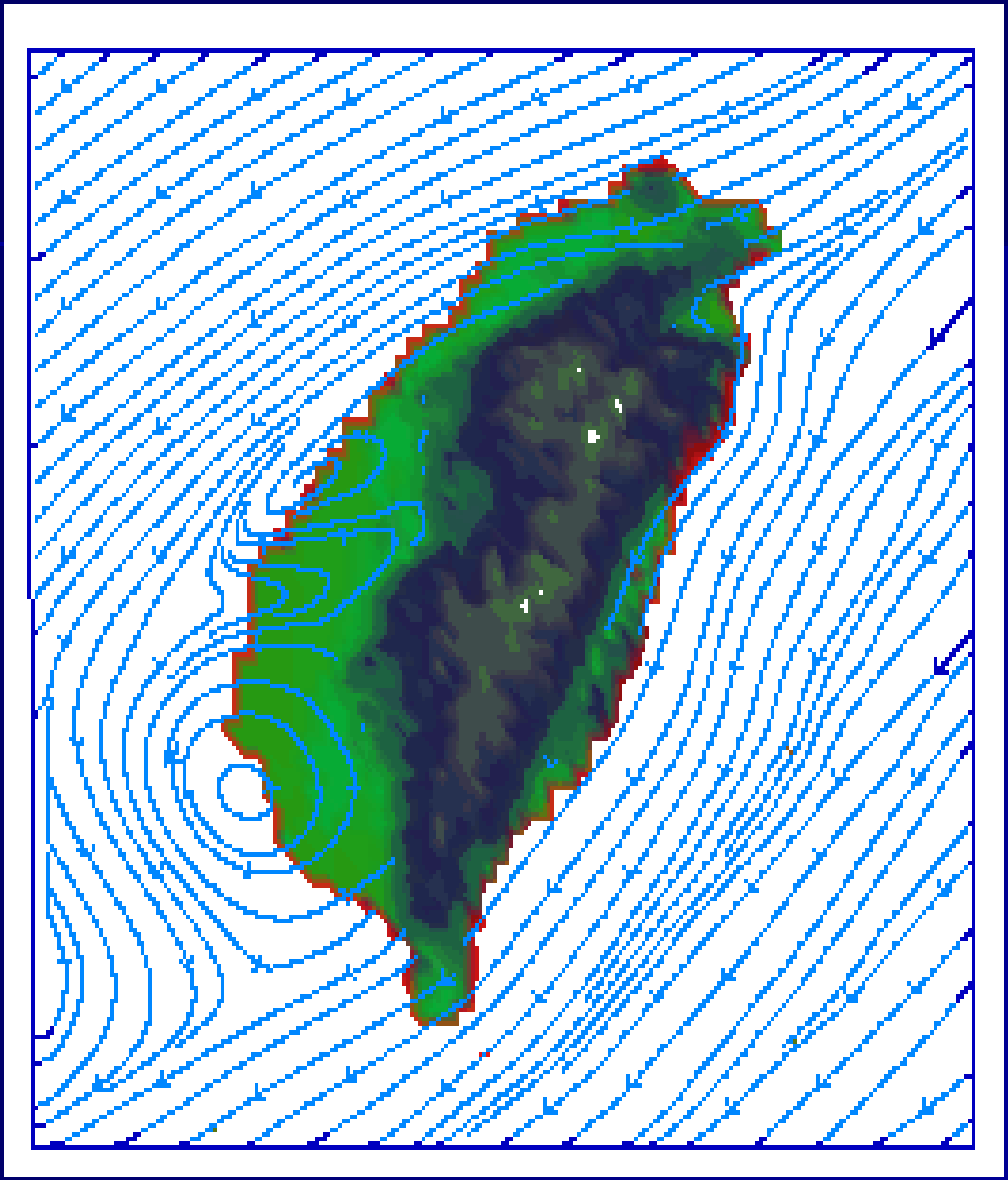

0.067115
0.056
0.032
0.008
-0.015
-0.039
-0.063
ppmV
1
1
14-Dec 08:00
75
14-Dec 14:00
14-Dec 18:00

NOx


0.245115
0.215
0.111
0.007
-0.098
-0.202
ppmV
1
1
14-Dec 08:00
75
14-Dec 14:00
14-Dec 18:00

NO2+O3


0.025115
0.021
0.009
-0.003
-0.015
-0.027
1



Unpair Maximum Hourly O_3 Concentrations in Different Scenarios

	Case A - Case B*			Case C - Case B*		
	Average	Max	Min	Average	Max	Min
west sites*	-0.04±0.64	1.13	-1.58	-1.19±2.98	3.13	-9.35
central sites*	0.79±0.71	1.93	-1.06	2.97±3.66	9.19	-4.38
downwind sites*	0.47±1.21	3.70	-1.66	1.61±3.26	9.19	-5.15

NMHC/NOx Ratios in Morning Hours

	Sites	Average	Max	Min
West Sites	2	9.3±1.3	10.4	8.04
Central Sites	8	11.0±1.3	12.7	10.1
Downwind Sites	3	22.2±2.3	24.6	19.0

Conclusions

- The model-simulated results were in fair agreement with observed data.
- Highways contributed abound 14% and 4.6% of NOx and NMHC, respectively, to the total anthropogenic emissions in Taiwan.
- The ozone concentrations decrease along the highway because of the effect of NO titration.

Conclusions

- The ozone concentrations were greater at the further downwind sites due to the photochemical reactions between NOx emitted from the second highway and biogenic VOCs.
- The ozone concentrations may vary significantly with the changes of highway networks for the same total emission.
- The variations of ozone concentrations were due to the changes in emission locations of NOx.

Acknowledgements

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