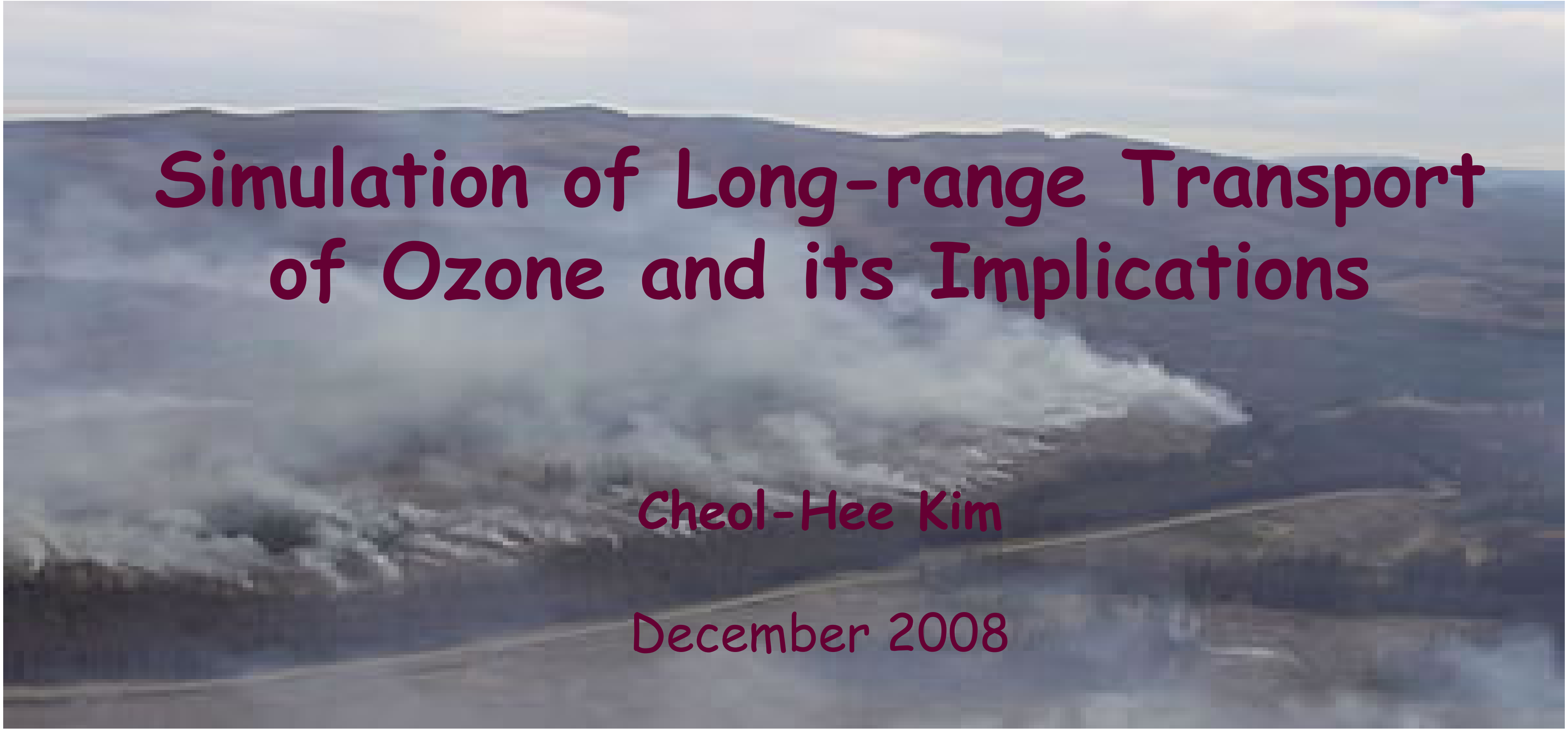

Simulation of Long-range Transport of Ozone and its Implications

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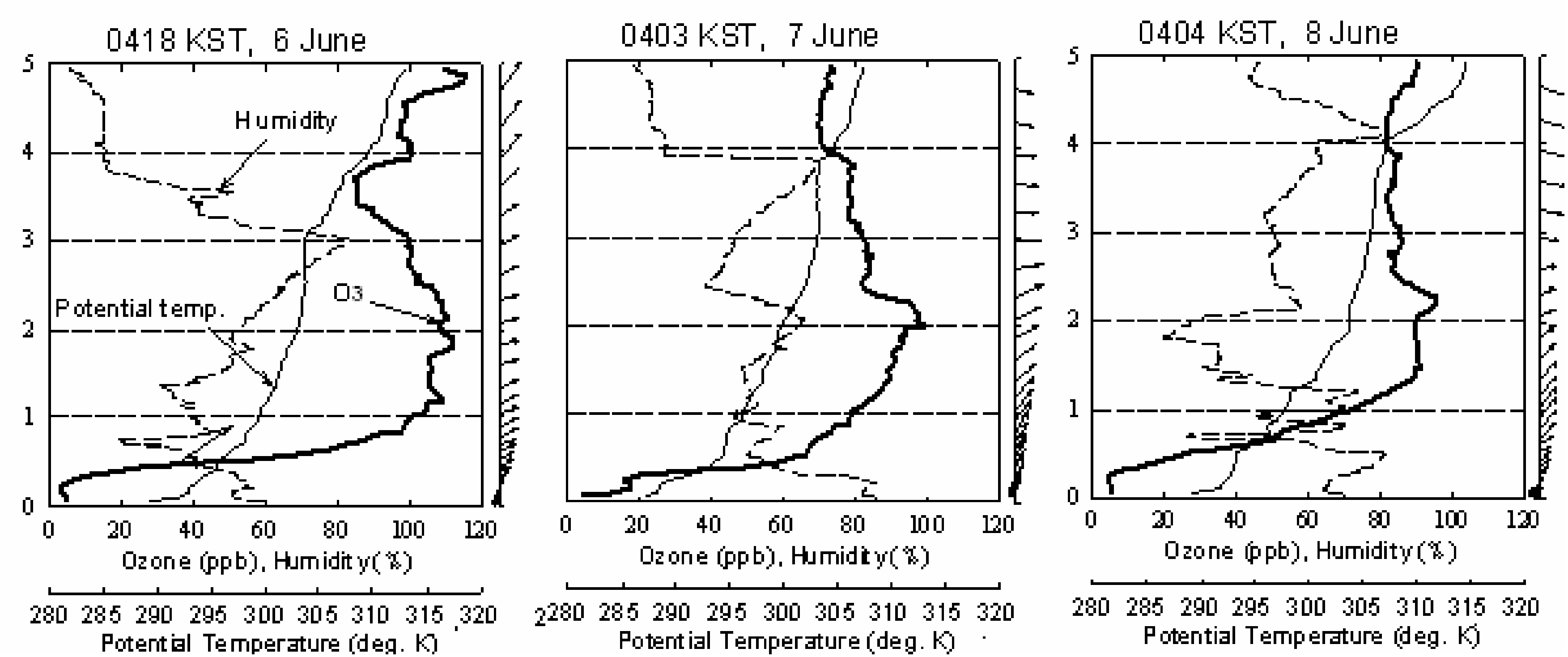
Outline

- I Introduction
- II Data Used
- III Model Configuration
- IV Results and Discussion
- V Summary & Conclusions

Introduction

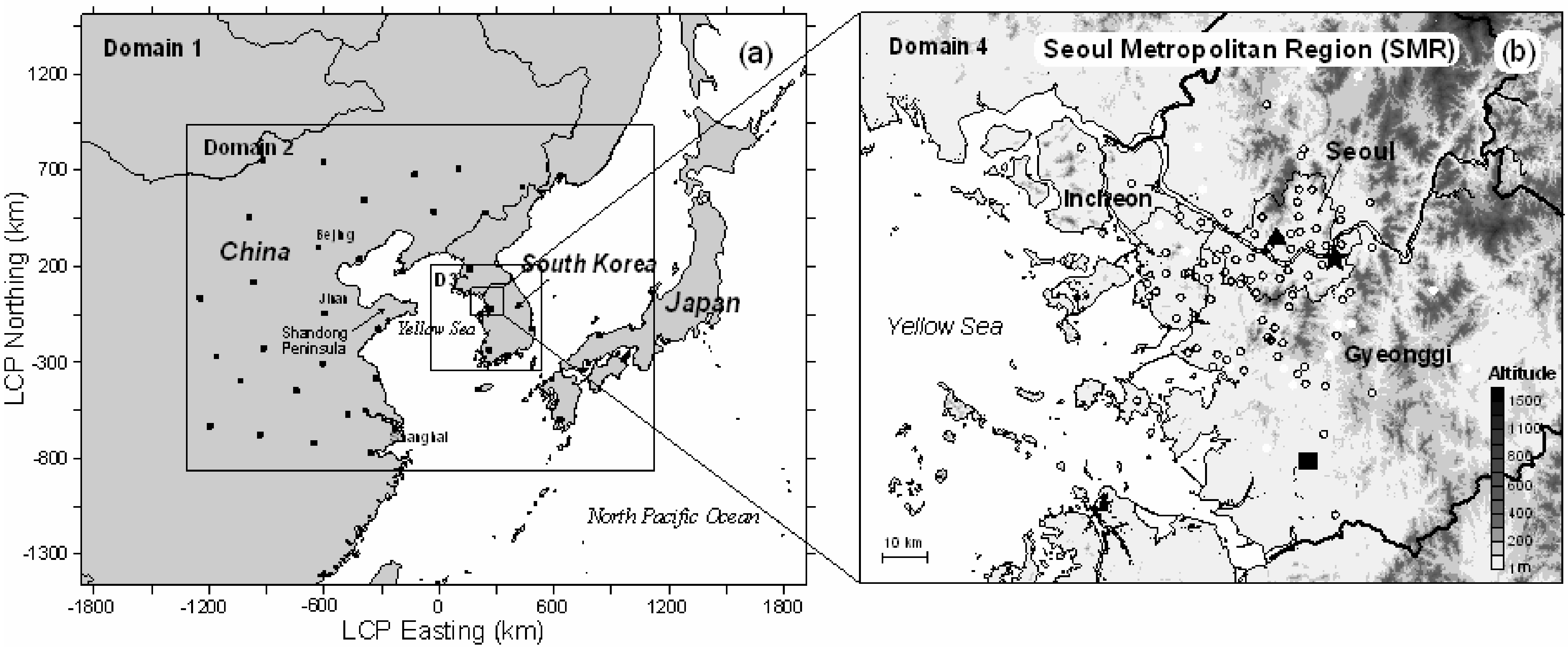
- Vertical O_3 distribution Over North-East Asia
  - Regional and Local emission effects
  - Mesoscale circulation and Convective mixing
  - Elevated O_3 layer and Long-range transport
- Previous Results
  - Modeling (i.e., Yamaji et al., 2006; Ahang et al., 2002)
  - Measurement (i.e., KME, 2007; Komhyr et al., 1995)
    : High regional background O_3 concentration are reported
- This Presentation
  - Examine the vertical O_3 profiles measured in Seoul
  - Modeling Study using MM5-CMAQ
  - Quantitative Estimation of the transported O_3 aloft to Surface Ozone Concentrations

-Measured vertical O_3 distribution



Data Used

- Measurement of vertical O_3 distribution
  - Period : 6 – 9 June, 2003
  - Ozonesonde Measurement at Seoul Olympic Park (SOP)
  - Meteorological data used for the same period



O_3 measurement(SOP)(★), surface meteorology(▲), air sounding(■), Surface O_3 sites (open circles)

Model Configuration

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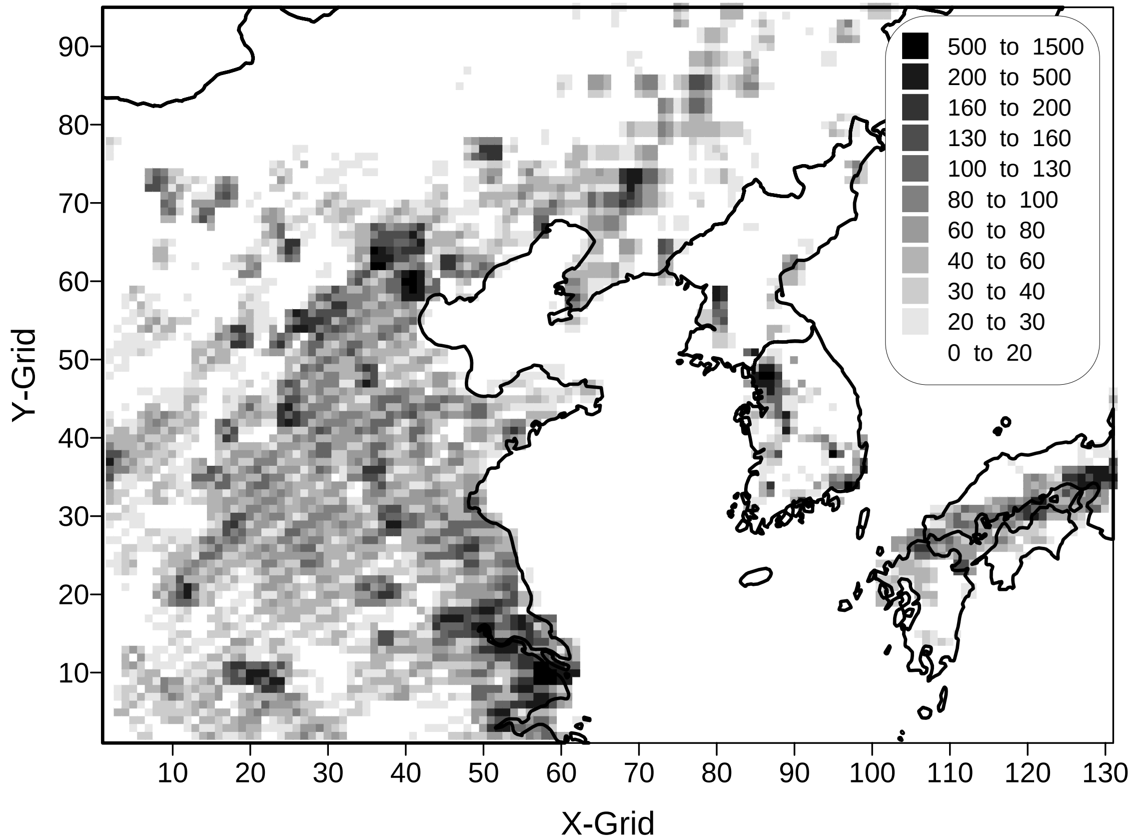
- Meteorological Model
  - MM5 (version 6.3)
  - Nested Grid System : 54 km(64×49), 18 km(130×94), 2 km (79×64)

- Air Quality Model
  - CMAQ (version 4.5)
  - Chemical Mechanism: SAPRC99
  - Emission
    1. CGRER (NASA INTEX-B project)
    2. Korea (CAPSS)
    3. BEIS 3.12 (Biogenic emission)



NOx emissions (ton yr-1)
(2006 emissions of INTEX-B project of NASA)

Results and Discussion

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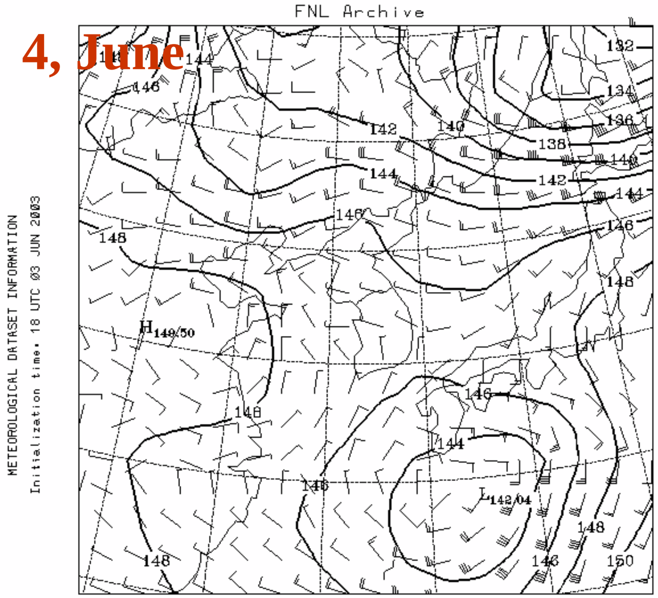
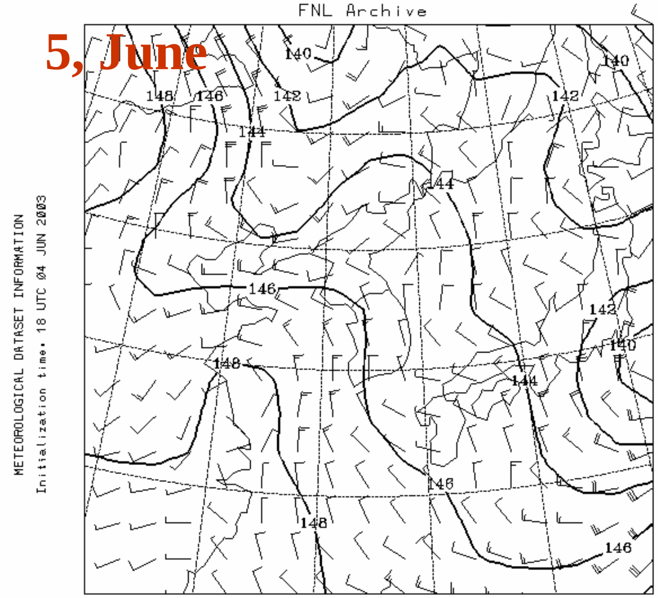
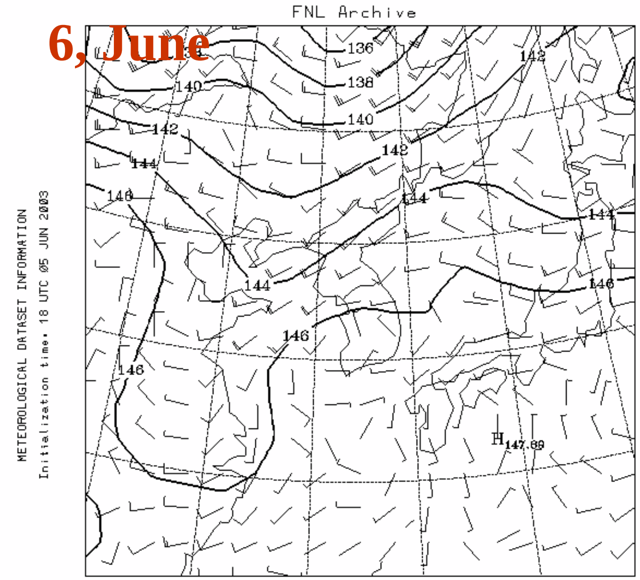
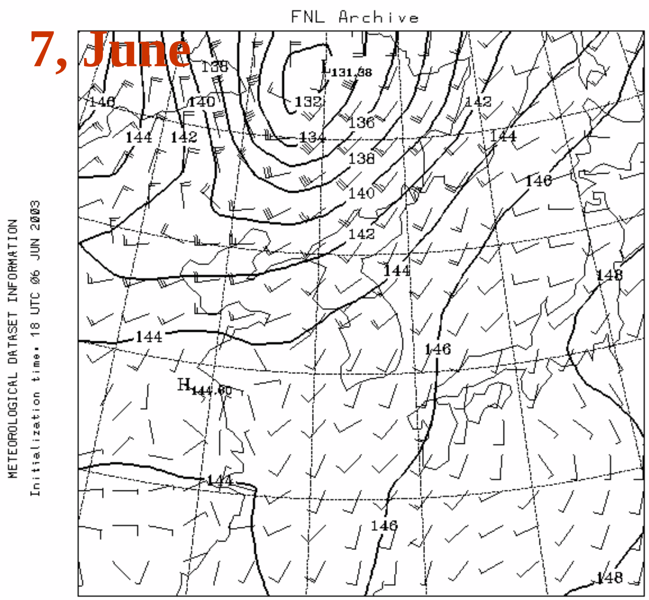
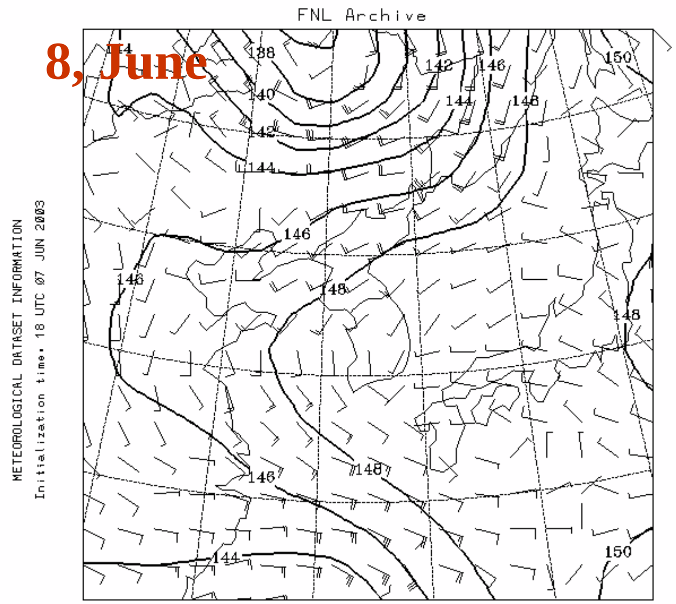
-Synoptic Condition

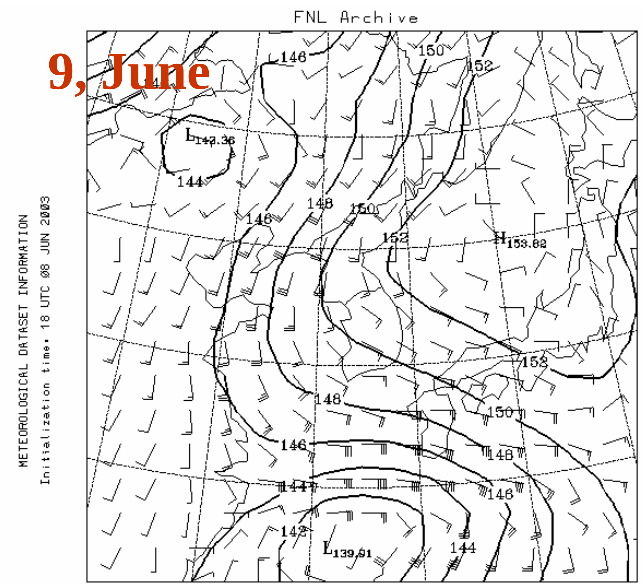












Results and Discussion

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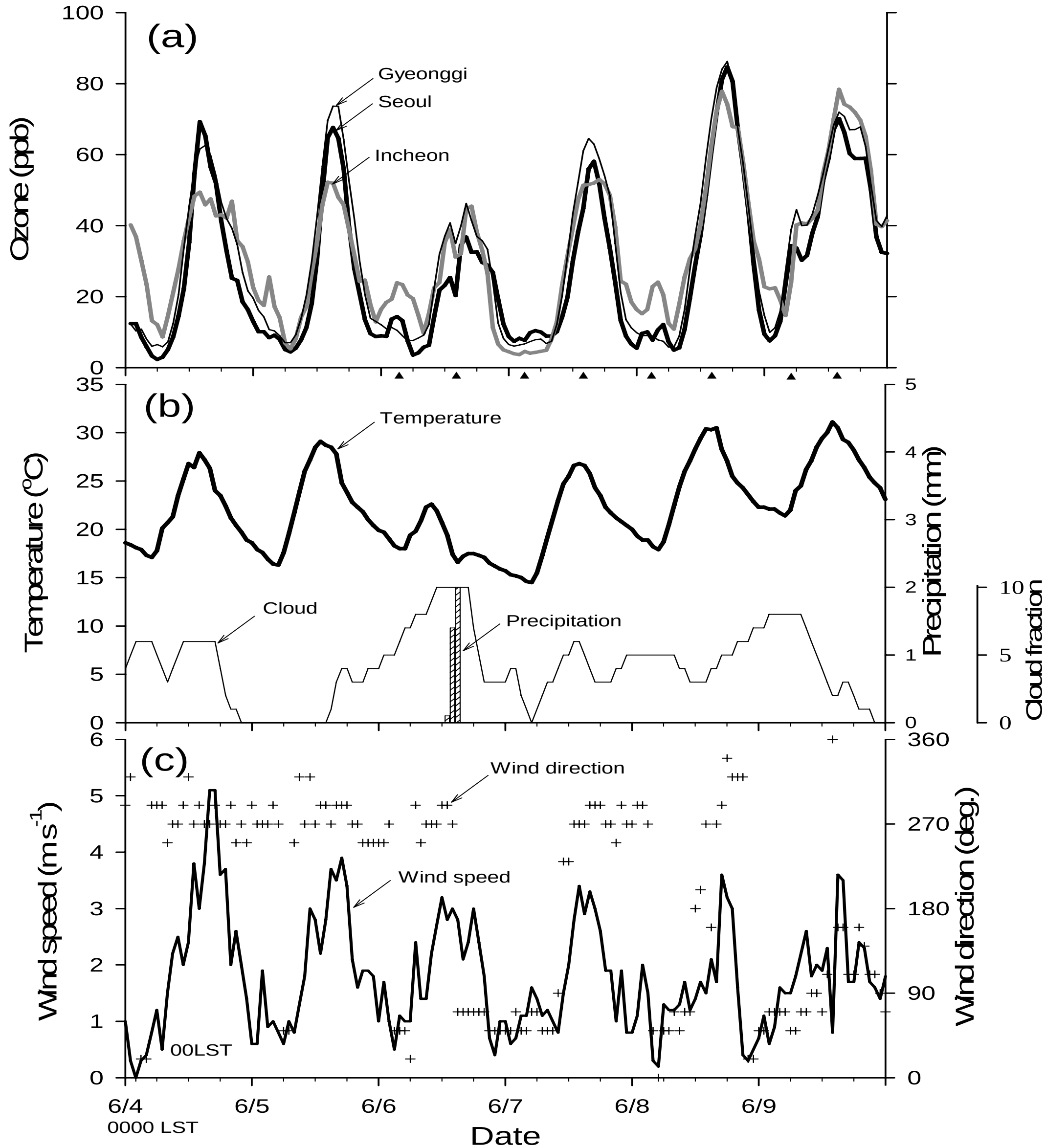
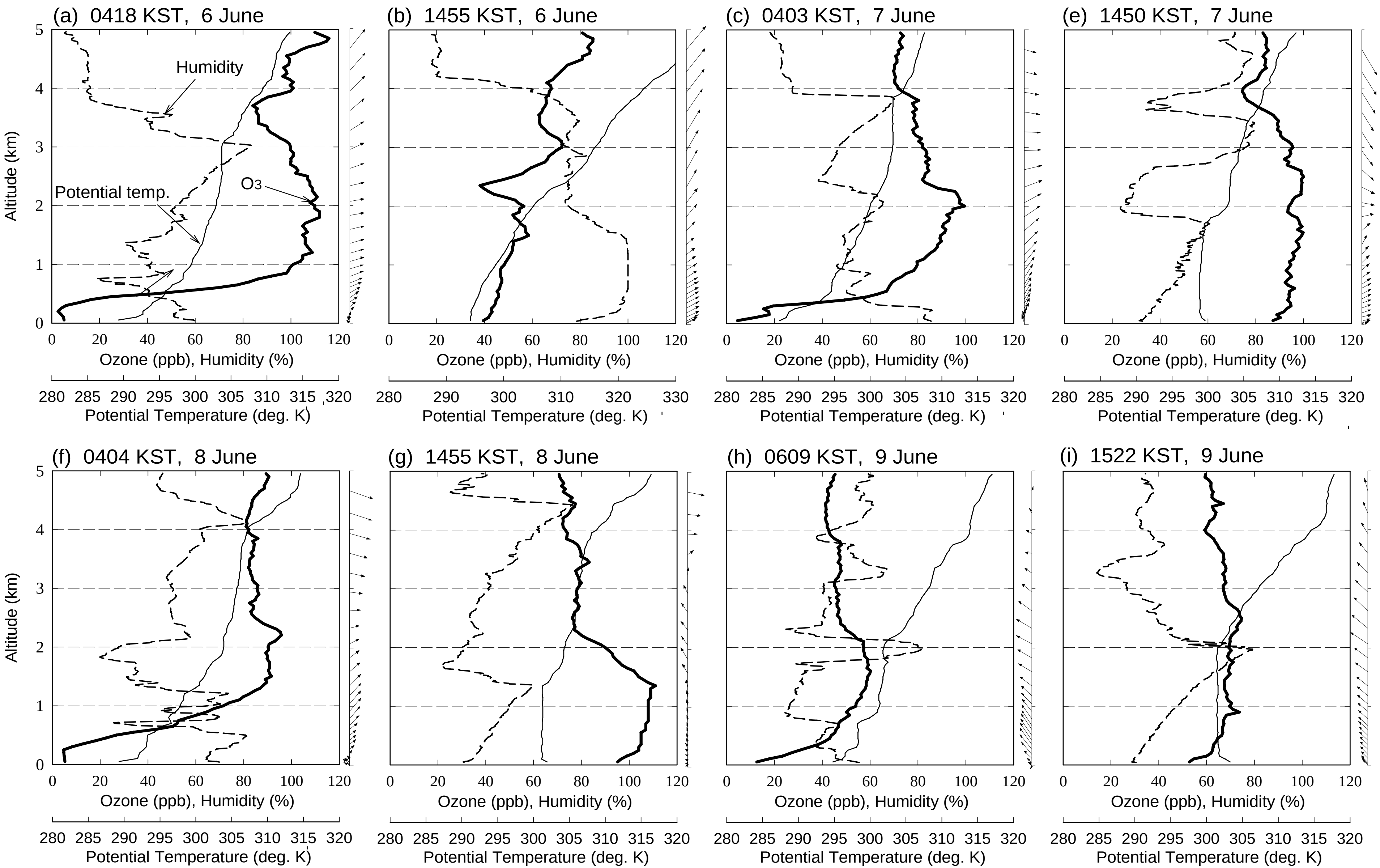
-Measured surface O_3 and Meteorological variables



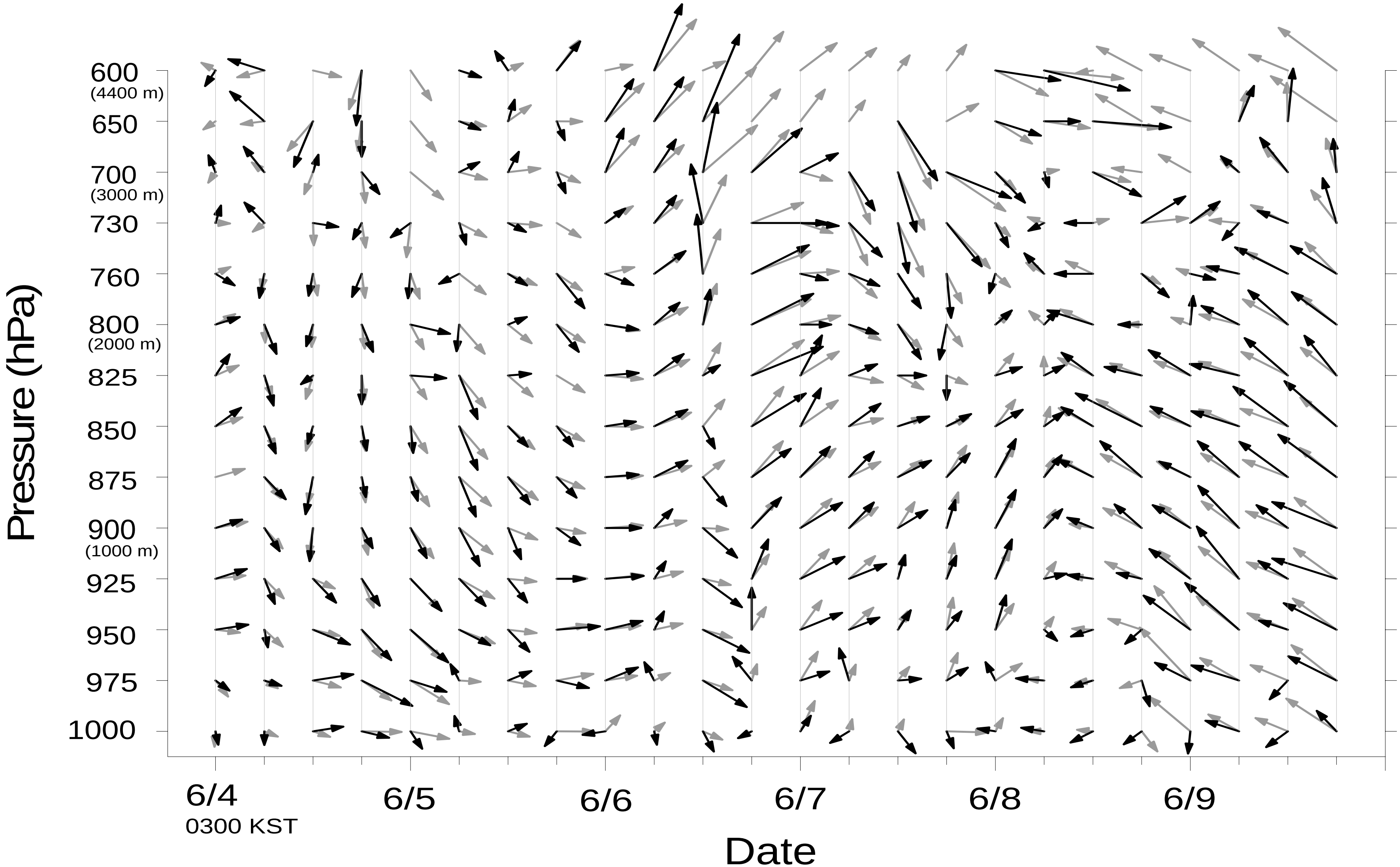
Results and Discussion

-Vertical O_3 distribution



Results and Discussion

Observed vs. Simulated Wind Fields



Modeled wind profiles (arrows with grey line). Observations (arrow with black line)

Results and Discussion

Meteorological Model Evaluation

Statistical measures	Temperature (K)	Winds (m s-1)		
		Wind speed	u-Comp.	v-Comp.
Mean bias, MB	0.21	-0.58	-0.06	0.03
Root mean square error, RMSE	1.10	2.06	2.07	2.17
Correlation coefficient, R (p<0.01)	0.98	0.85	0.91	0.90
Number of samples	1305		1353	

Results and Discussion

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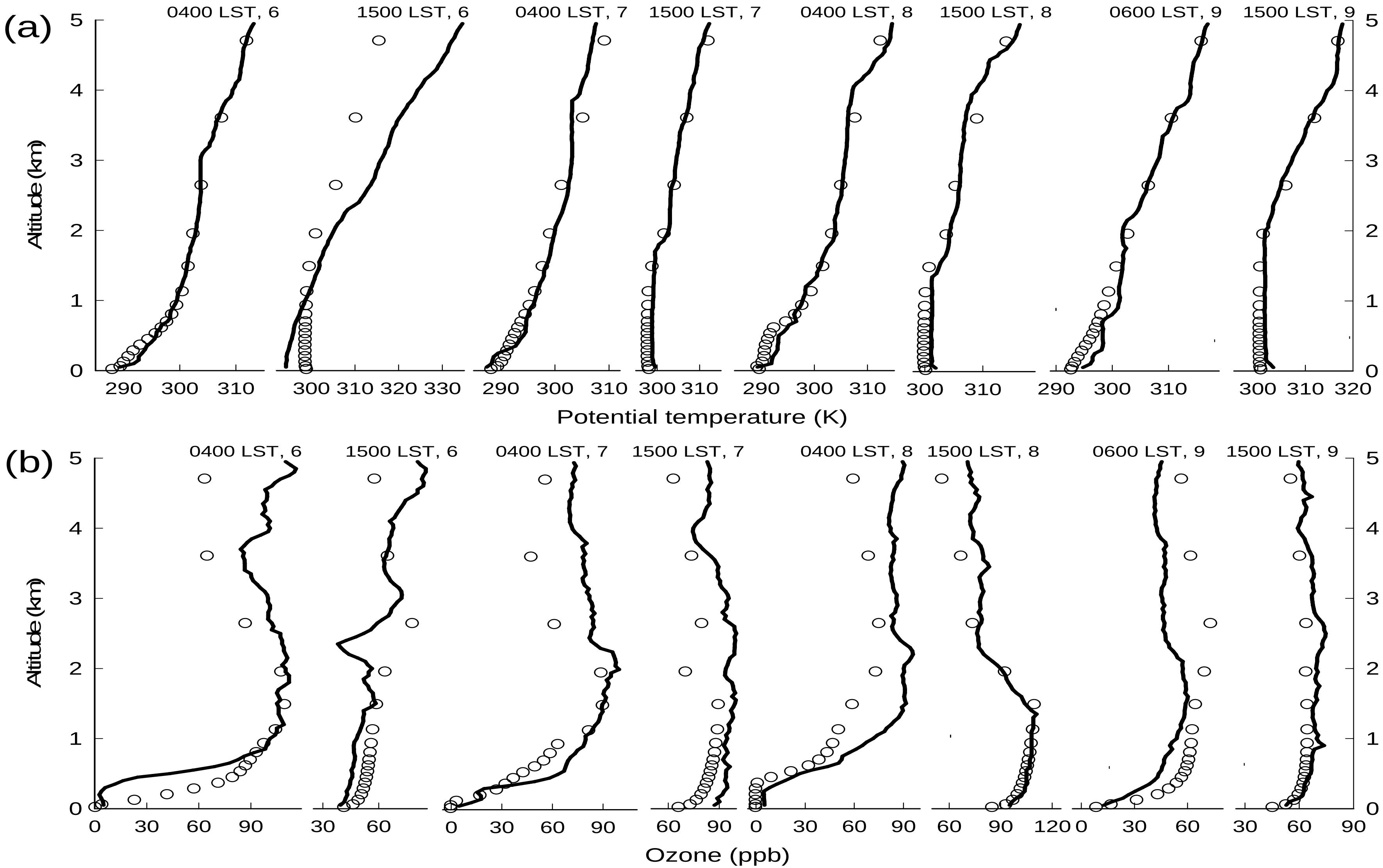
Observed vs. Simulated Potential T., and O_3



Observation (line) vs.Simulation (circle) for (a) Potential Temp. (b) O_3

Distributions of the modeled O_3 and wind vectors at 2 km

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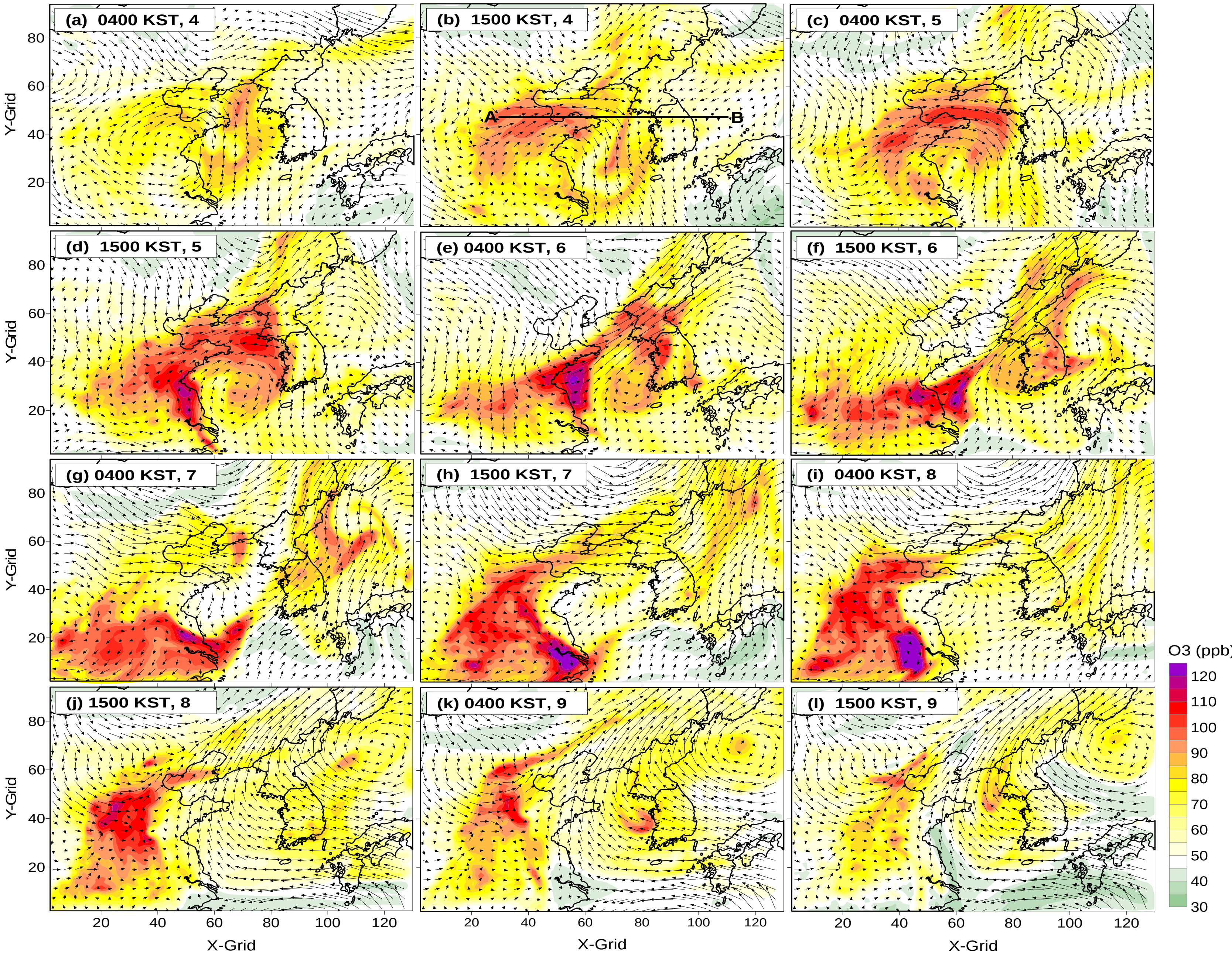

Cross-section (A–B) of O_3 & potential temp.

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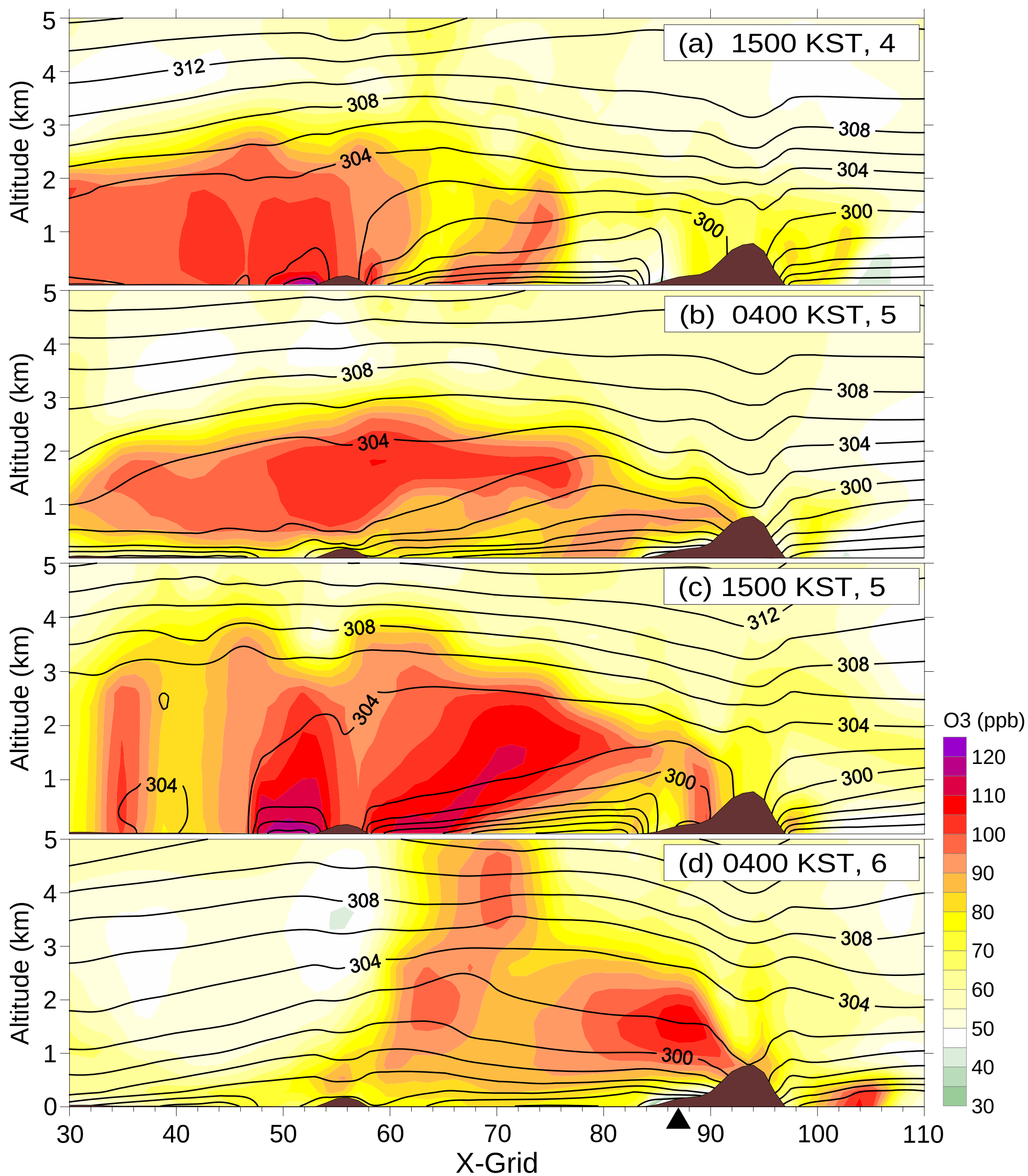

Results and Discussion

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Implications (1)

- Elevated O_3 concentrations over 100 ppb was simulated by upward transport of photochemically generated O_3 concentrations in deep mixed layer

- O_3 were mostly confined to two levels of isentrophic surface (Elevated O_3 decoupled from stable air + surface O_3)

- High elevated O_3 concentrations was seen next day over the Yellow Sea, and modeled high O_3 concentrations extended across the Yellow sea due to the regional transport of O_3 concentrations periphery of the high pressure system

- The elevated O_3 concentrations later have been long-range transported over the Yellow sea with favorable weather condition

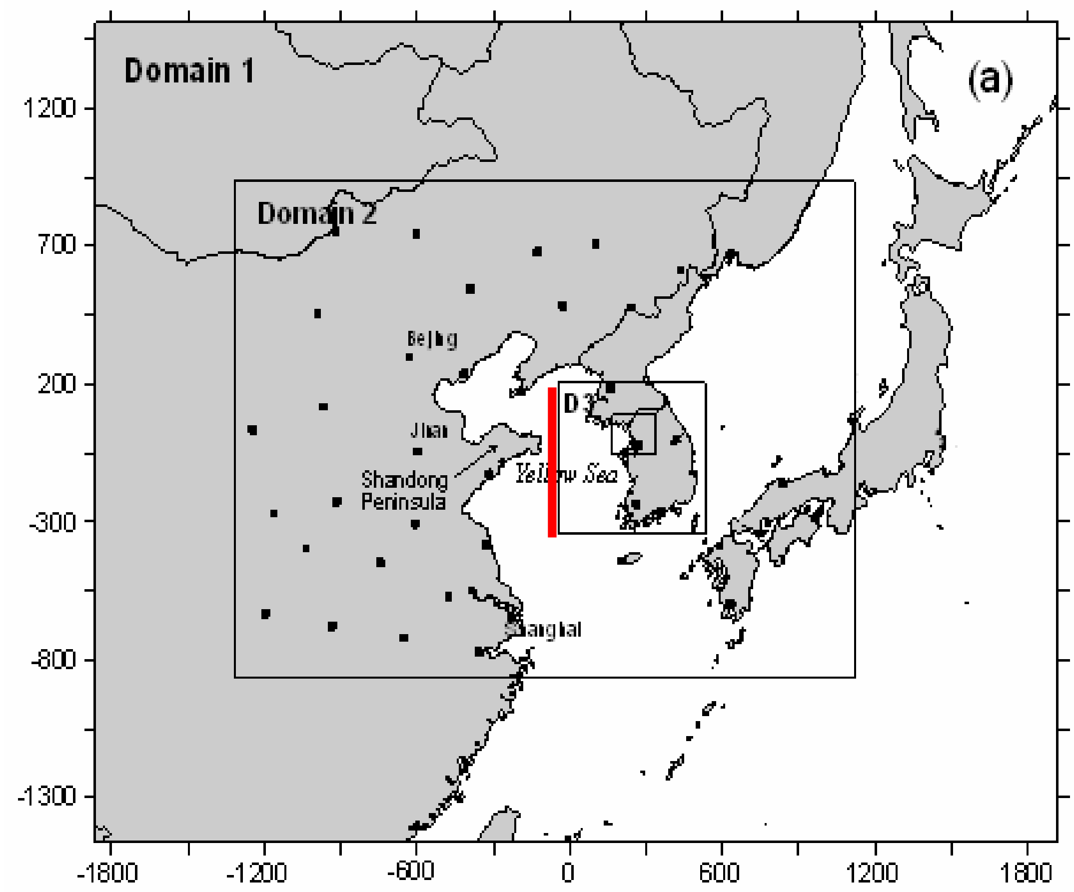
Sensitivity Tests

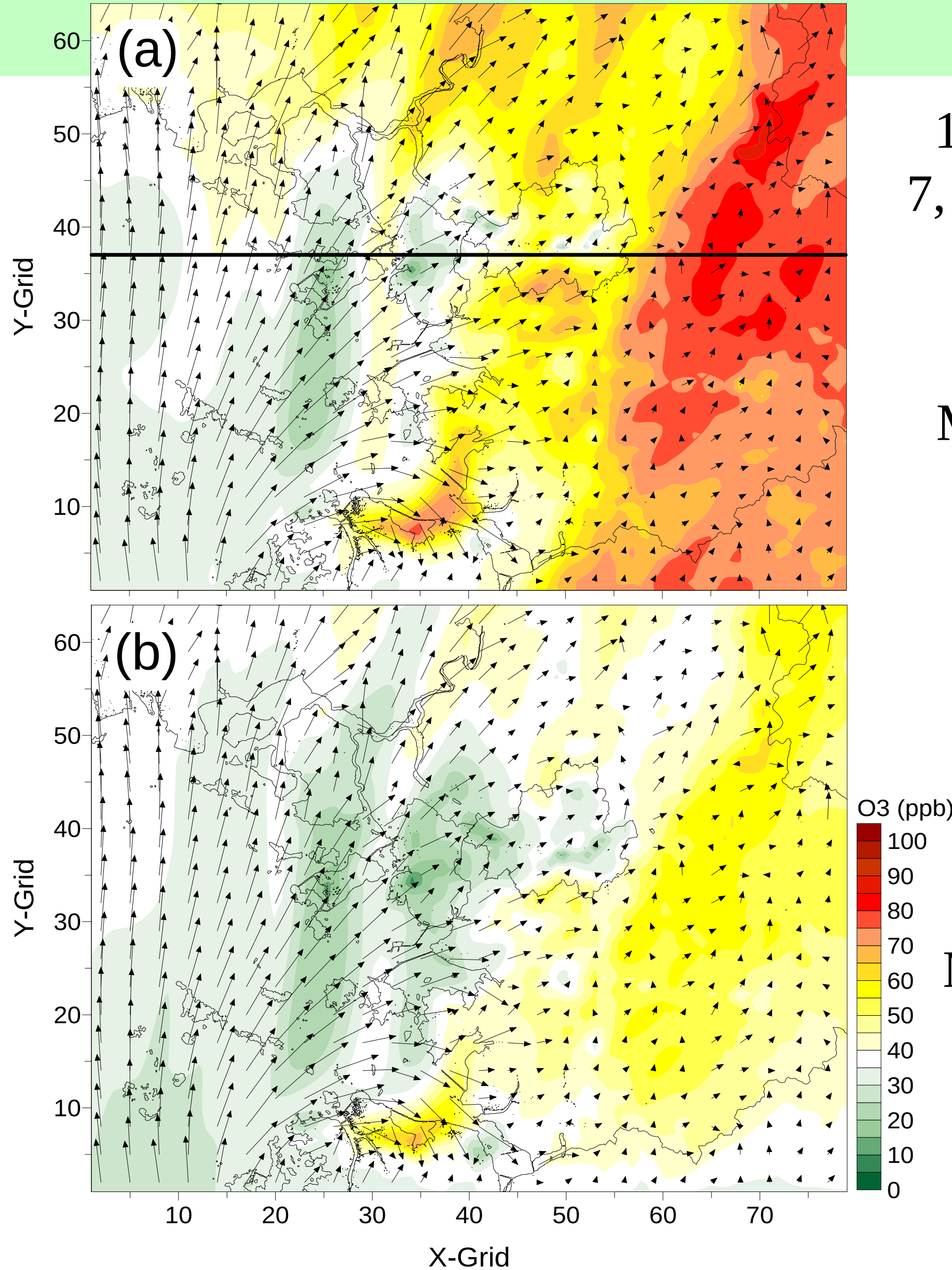
Long range Transport + Well-developed Mixed Layer

- **MM5-CMAQ Simulations**

- **Case 1:**
  Nested Boundary Condition from Coarse Domain

- **Case 2:**
  Clean Air condition Boundary Condition





1300 LST
7, June 2003

CASE 1
Max. 76.5 ppb

CASE 2
Max. 34.7 ppb

Modeled surface O_3 and wind vectors

Results of Sensitivity Test

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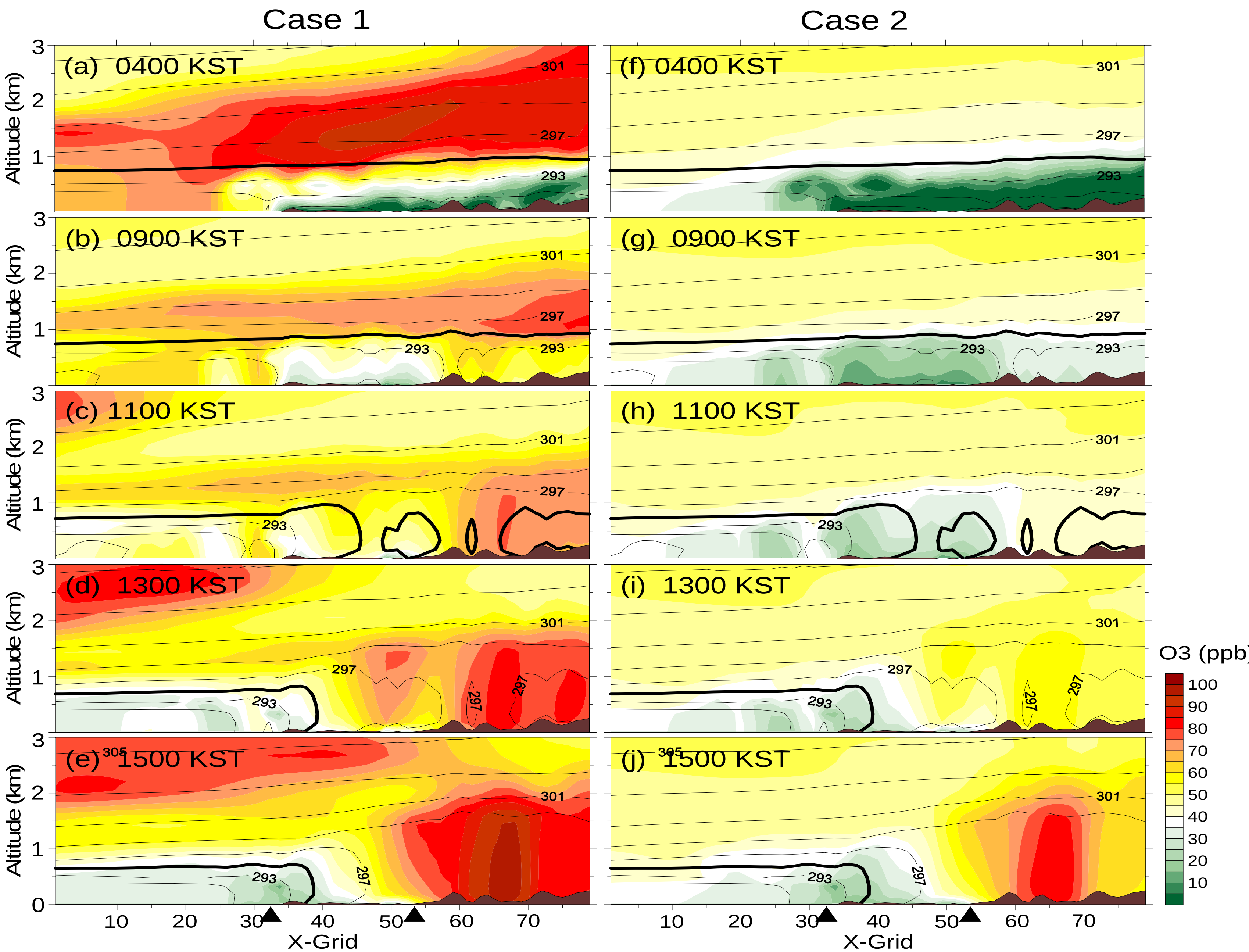

Results and Discussion

Implications (2)

- Maximum difference of O_3 between Case 1 and Case 2 is 41.8 ppb
  Case 1 : 76.5 ppb
  Case 2 : 34.7 ppb
- Surface O_3 concentrations can be enhanced by up to 55 % cause by regional transport process.
- Depending on the levels of O_3 aloft, the enhancement was significant

- Previous Studies
- 1) Zhang et al.(1977) 60-70% by O_3 down mixing process at rural site
- 2) Neu et al. (1994) 50–70 % by O_3 trapped aloft in the overnight residual layer
- 3) This episodic study : 55% by O_3 transport and down mixing process

Summary and Conclusion

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- Ozonesonde measurements at SOP shows elevated O_3 layer at 1km-3km
- Multi-scale O_3 simulations by the MM5-CMAQ were made to identify the processes of regional scale transport and suggested the evidence of the elevated O_3 layer over Seoul
- (Photochemical O_3 Production + deep convection) -> (transported eastward over the stable marine boundary layer) is corresponding to the ozonesonde measurement at SOP and pointing to important regional influences in shaping the vertical O_3 distributions
- Sensitivity tests shows that about 55% enhancement of the surface O_3 concentrations is attributed to the regional influence
- The simulations suggested that the vertical mixing processes in the daytime convective boundary layer can bring ozone-rich air masses aloft, which was mainly formed by the long-range transport, down to the ground during the daytime


Thank you for
your attention