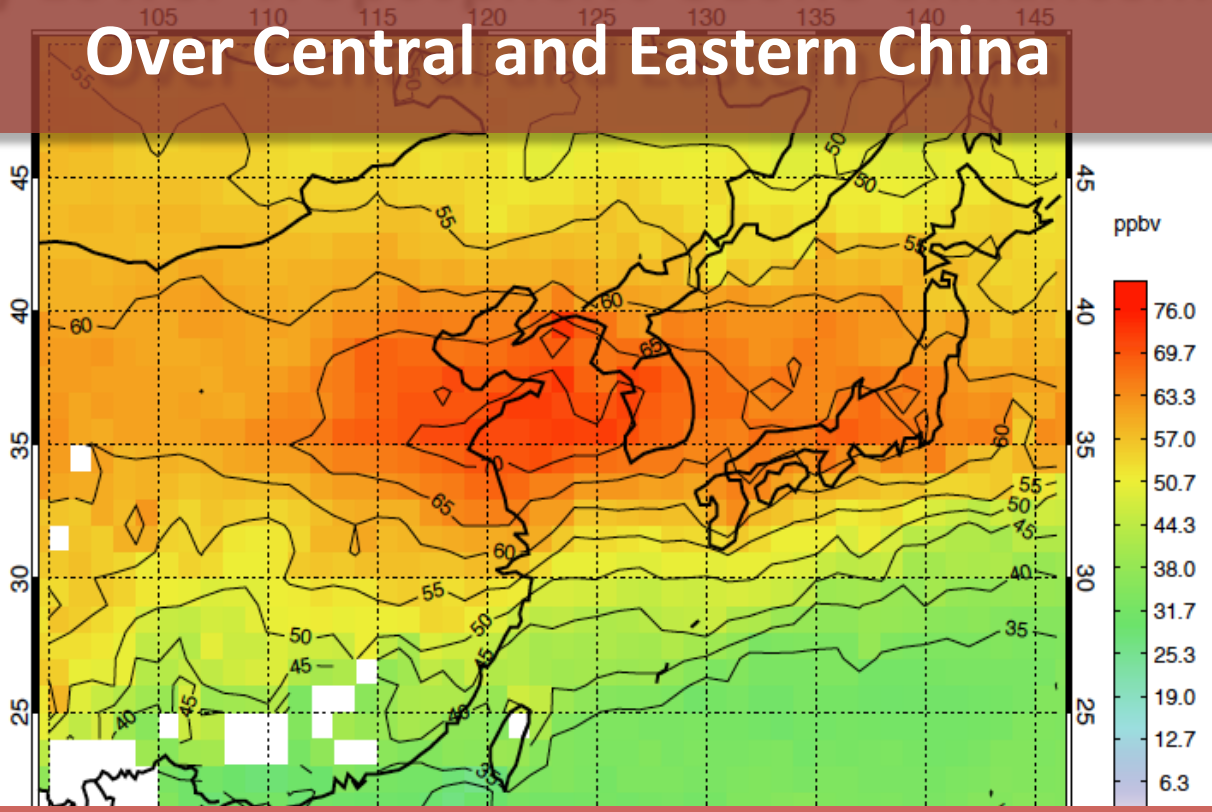
The 7th GEMS Science Meeting, Oct. 10-12, 2016

Comparison of OMI Observation with Model Simulations to Study Lower Tropospheric Ozone enhancement Over Central and Eastern China



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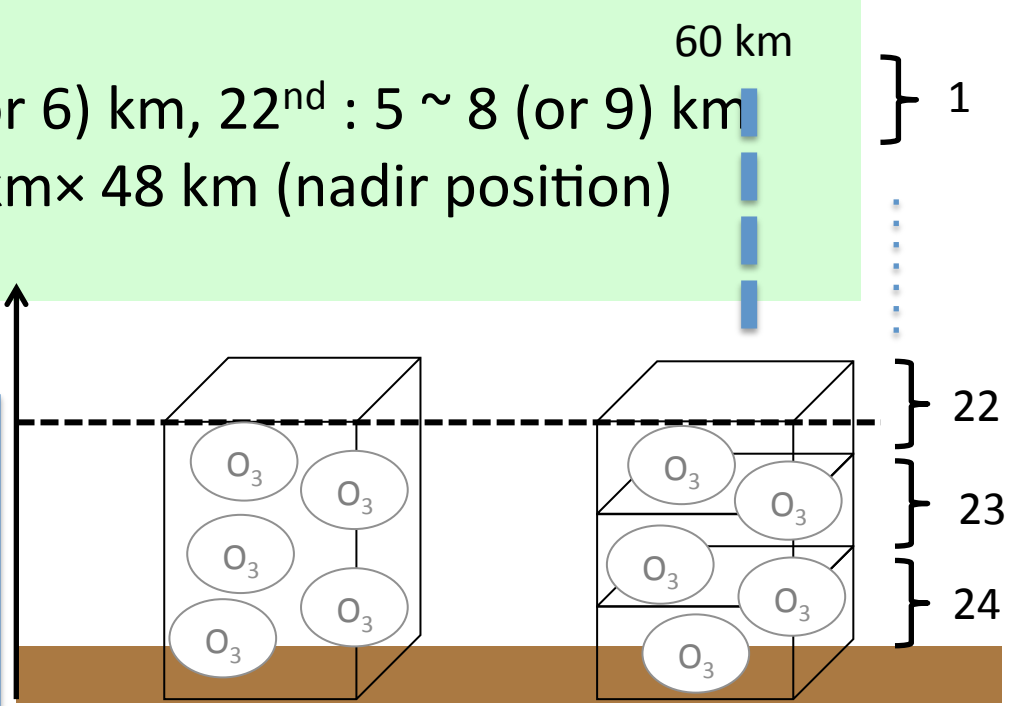
Introduction

- Ozone profiling is a big challenge of GEMS mission.
- 90 % of O_3 in the stratosphere, 10 % in the troposphere: only a few percent or even less in the boundary layer.
- The OMI product of ozone profiles suggests the possibility to detect lowe tropospheric O_3 from GEMS.

Satellite data: OMI

Liu et al., ACP, 2010: Xiong Liu and Kelly Chance successfully retrieved ozone profiles for 24 layers from OMI spectra, in 270-330 nm (270-309 nm in UV1, 312-330 nm in UV2), with 3-7 layers in the troposphere.

- Optimal estimation with climatology by McPeters et al. (2007) for a priori
- 24^{th} : 0 ~ 3 km, 23^{rd} : 3~5 (or 6) km, 22^{nd} : 5 ~ 8 (or 9) km
- Horizontal resolution of 13 km× 48 km (nadir position)



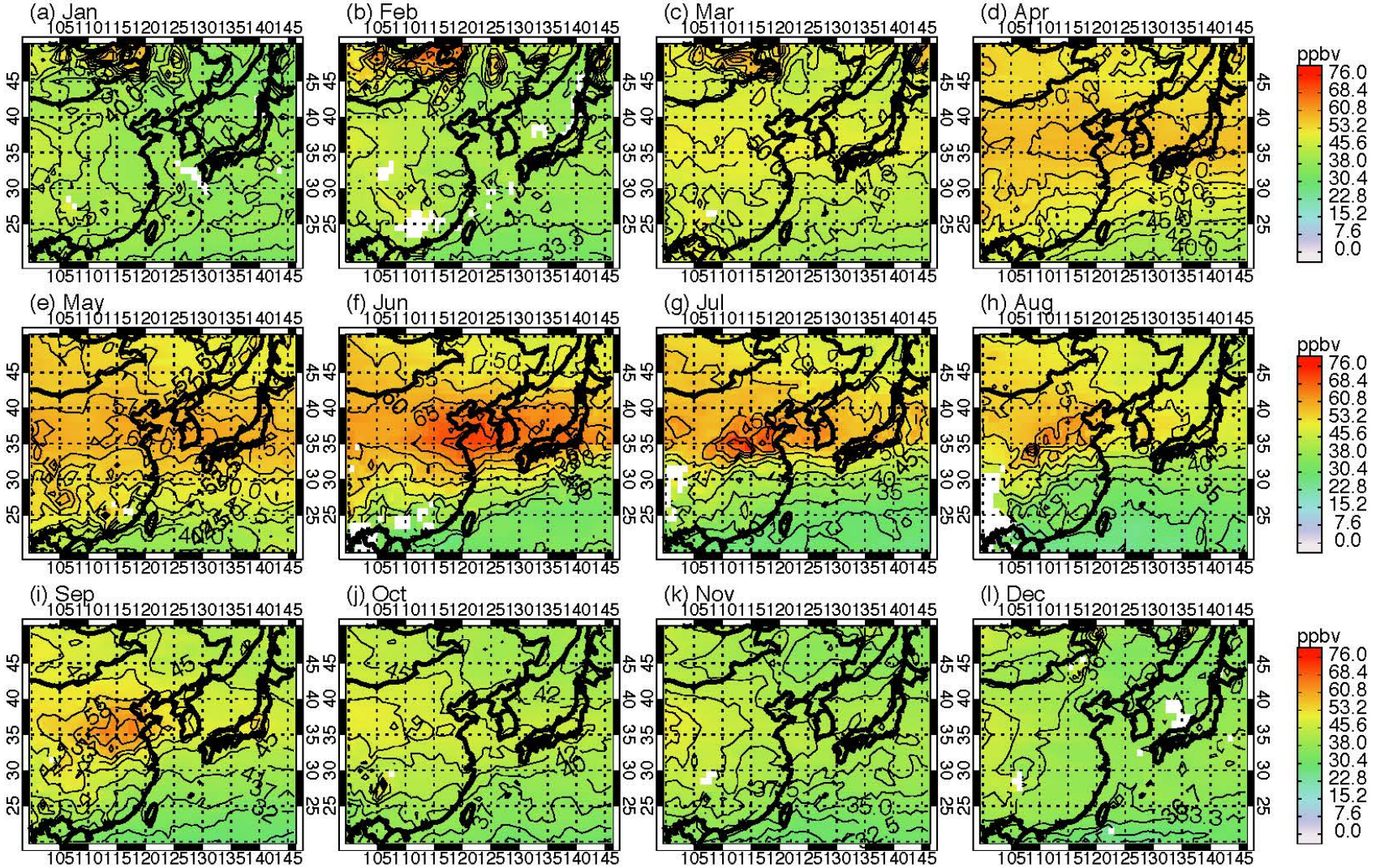
Our Analysis

Level 3: archived 1 x 1 deg.
Pre- screening
Cloud fraction < 0.2
RMS (UV2) < 2.4

OMI ozone profiles

- *S. Hayashida, X. Liu, et al.: Observation of ozone enhancement in the lower troposphere over East Asia from a space-borne ultraviolet spectrometer, Atmos. Chem. Phys., 15, 9865–9881, 2015.*
  - The lower tropospheric O_3 distribution maps were first obtained from UV measurements from space.
  - We showed significant enhancement of O_3 in the lower troposphere over central and eastern China (CEC).
  - We compared the OMI-derived O_3 profiles over Beijing with airborne measurements (MOZAIC) and demonstrated the reliability of OMI O_3 retrievals in the lower troposphere under enhanced ozone conditions.

OMI retrieval (the 24th layer:0-3km) Monthly mean in 2005



June is most outstanding in ozone enhancement

OMI retrieval (the 24th layer)
Monthly mean in June from 2005 to 2013

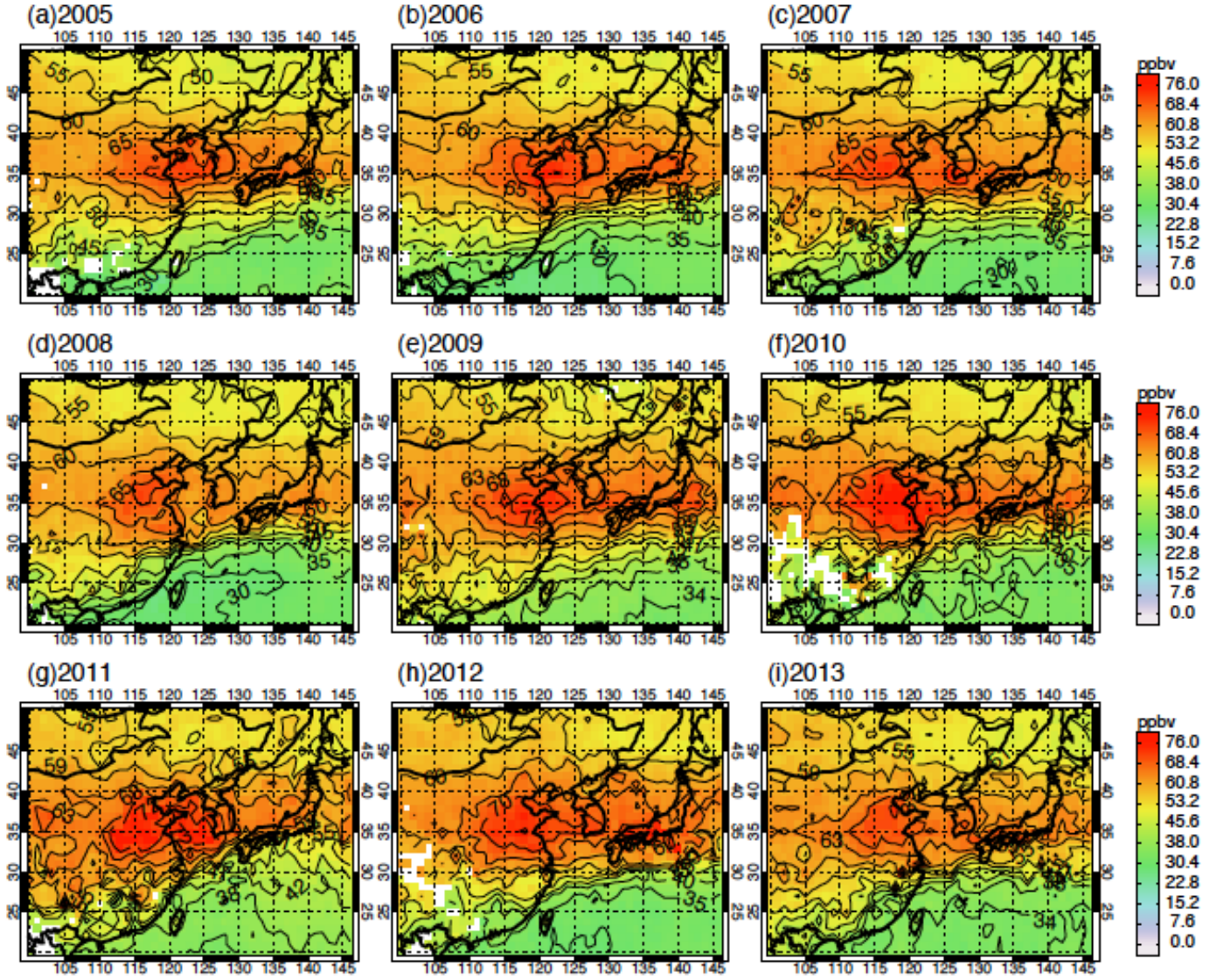
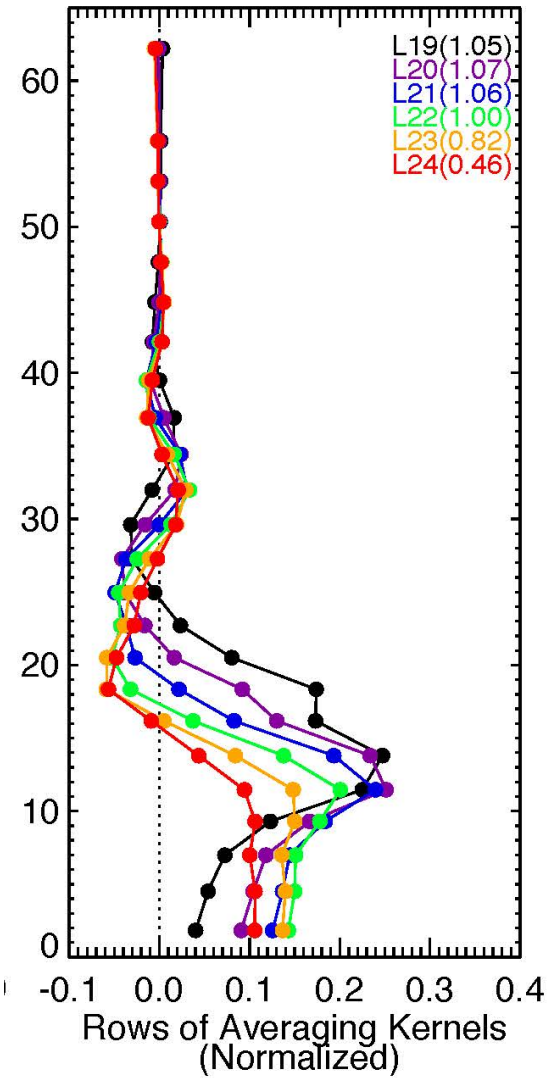


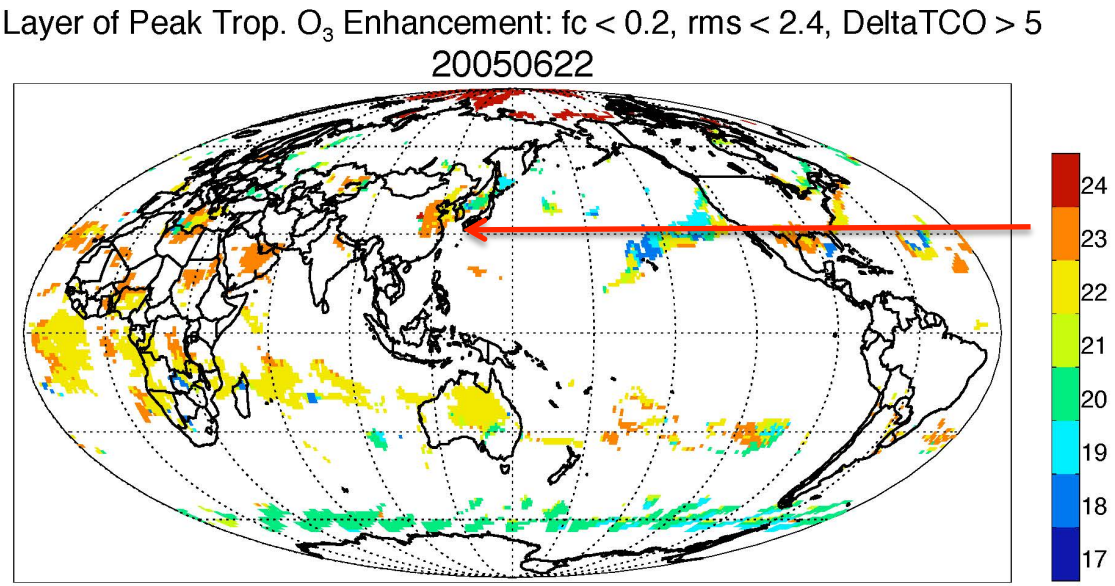
Figure 10. Maps of monthly mean values of retrieved ozone at the 24th layer in June from 2005 to 2013.

OMI: Averaging Kernels



Hayashida et al., ACP, 2015

For the enhancement of O_3 in UT/LS, the peak layer should be higher than 22nd layer



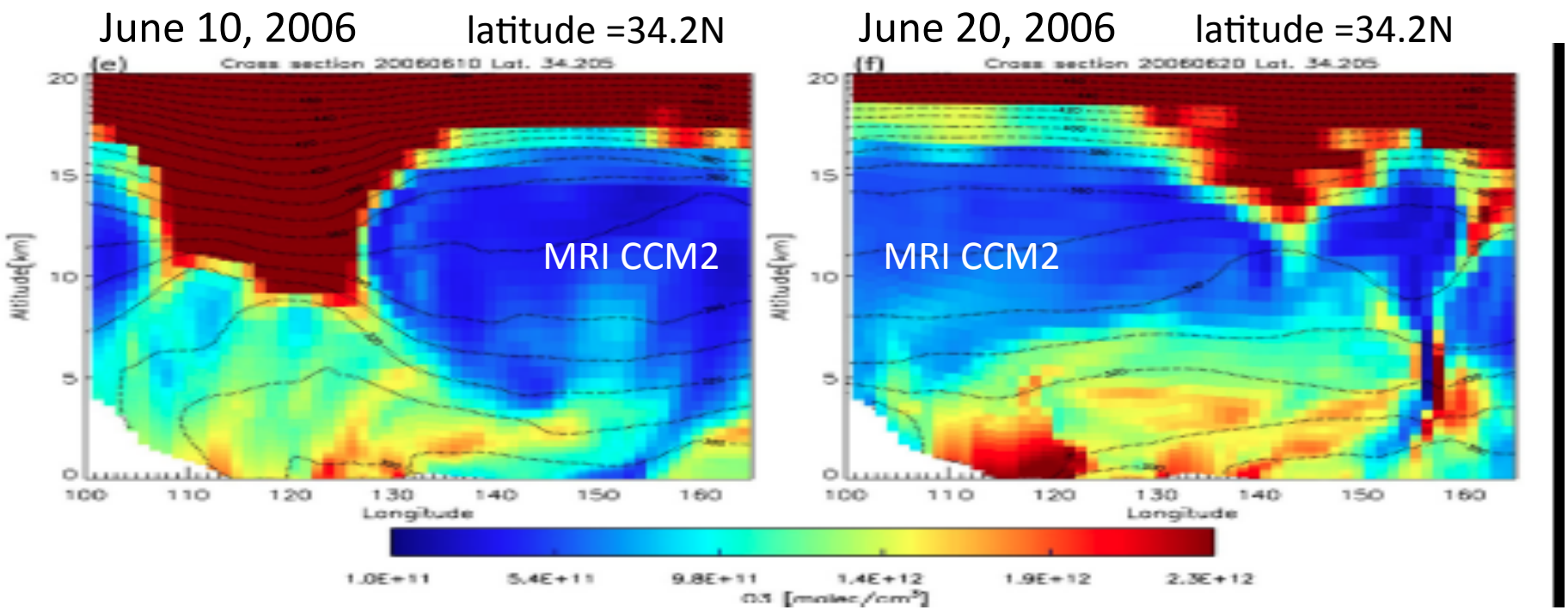
The enhancement of O_3 in UT/LS can affect on 24th layer O_3 to some extent.

=> need to remove the UT/LS effect to evaluate 24th ozone enhancement more quantitatively.

UT/LS screening for 24^{th} layer ozone

- We developed the scheme to eliminate the effect of UT/LS O_3 enhancement on the lower tropospheric O_3 derivation.
  - We analyzed the variation of O_3 in the UT/LS obtained by the MRI-CCM2 simulations.
  - We eliminated the cases in which the effect of the UT/LS O_3 variability on the 24^{th}-layer O_3 is considerably large.

Enhancement of UT/LS O_3 over East Asia related to the low-pressure system



MRI-CCMS: Meteorological Research Institute—Chemistry Climate Model
Deushi and Shibata (2011).

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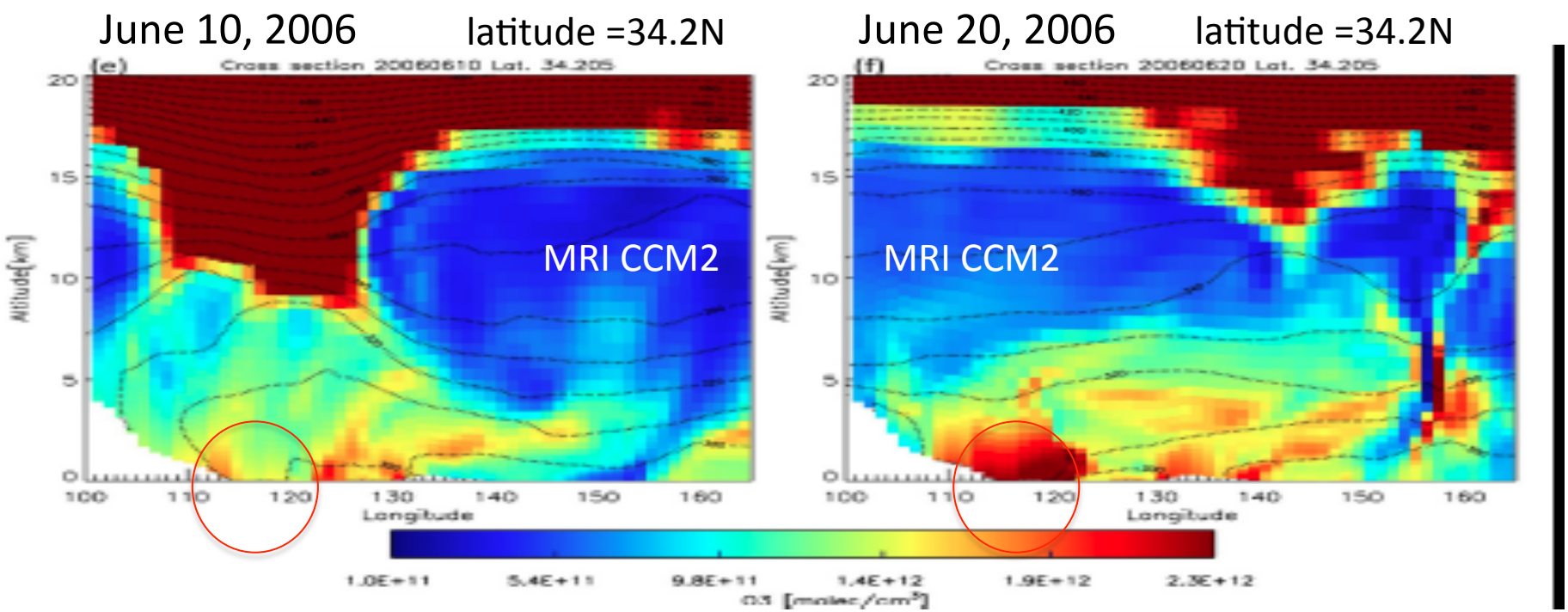

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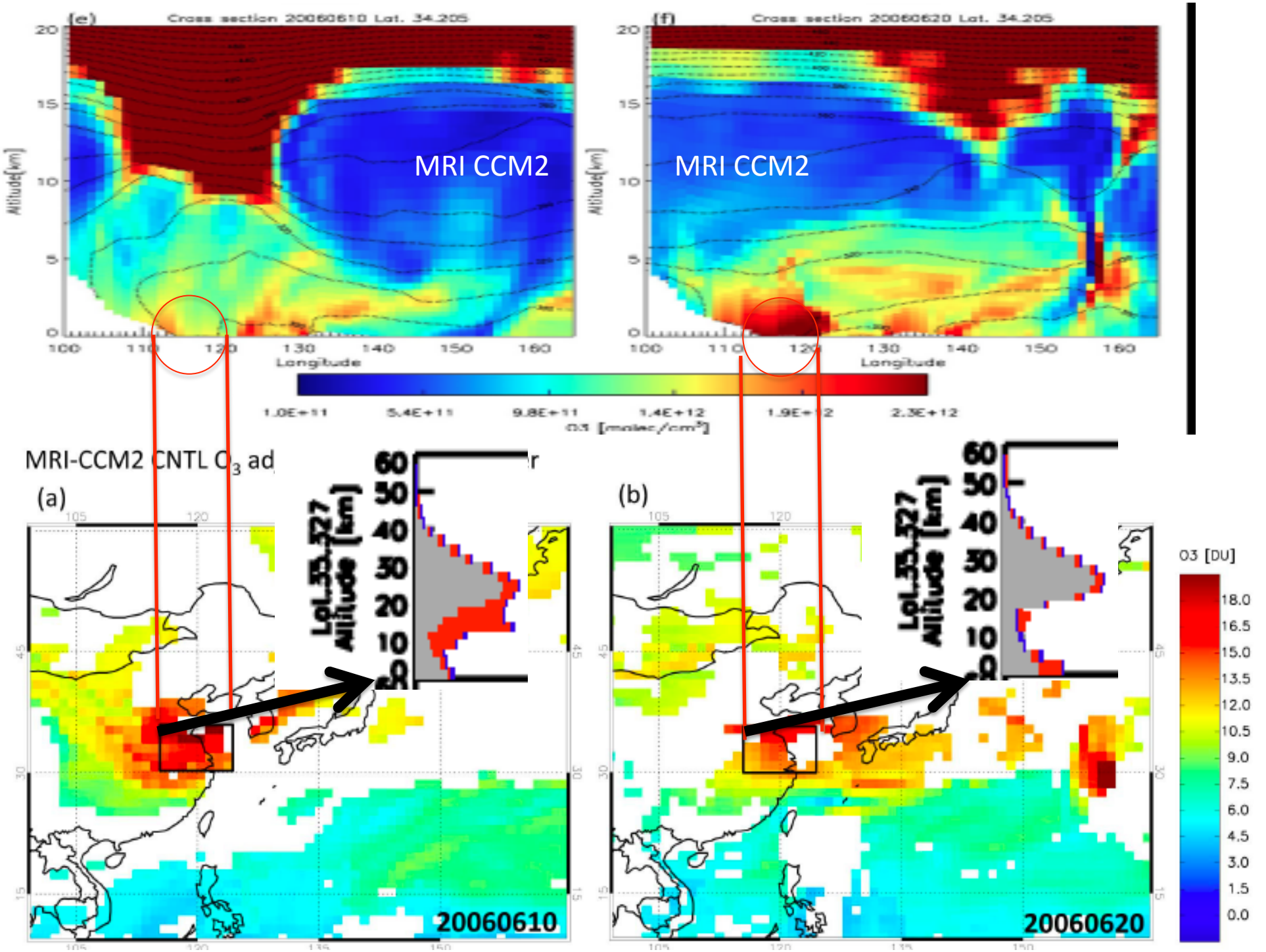
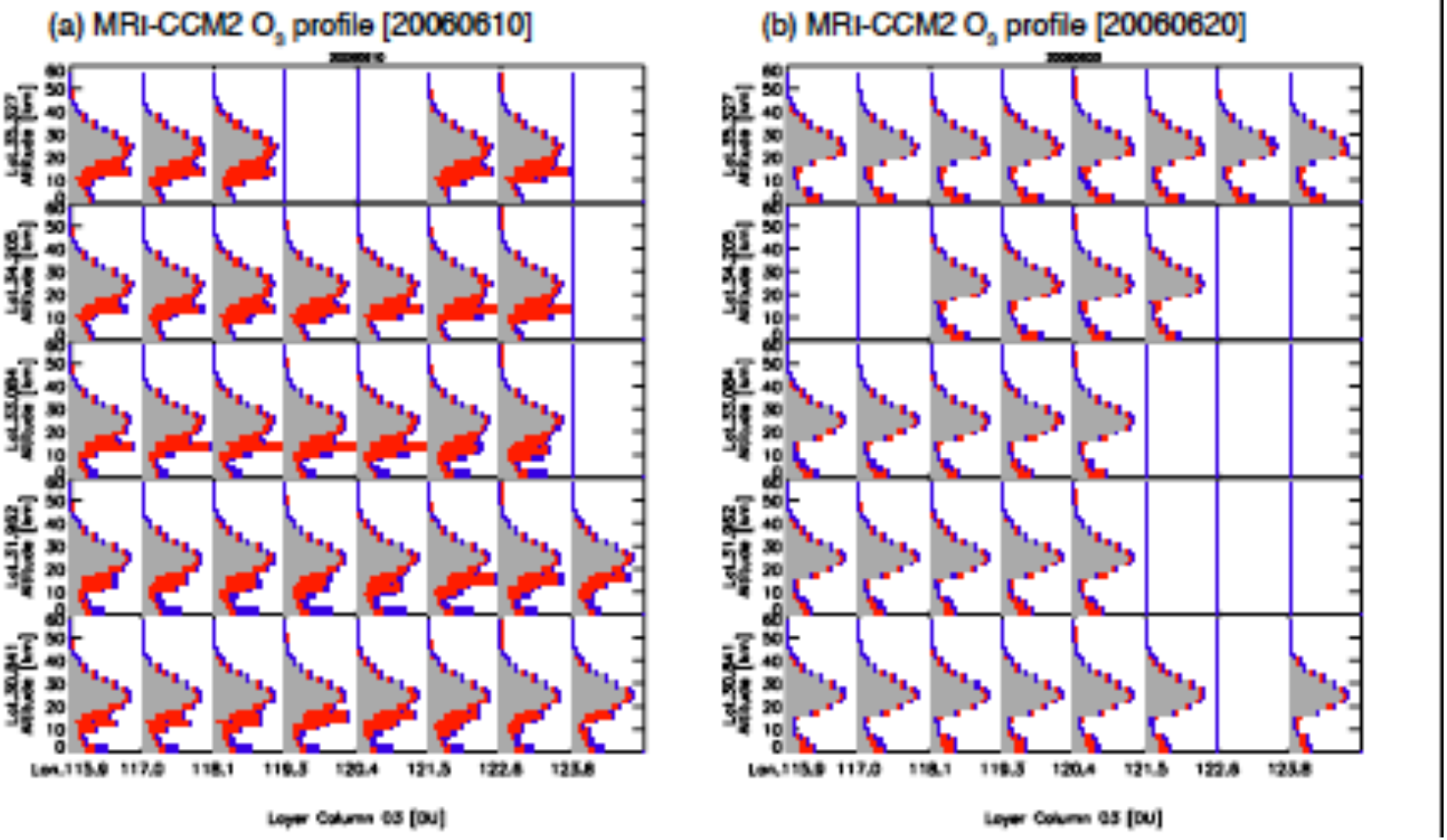
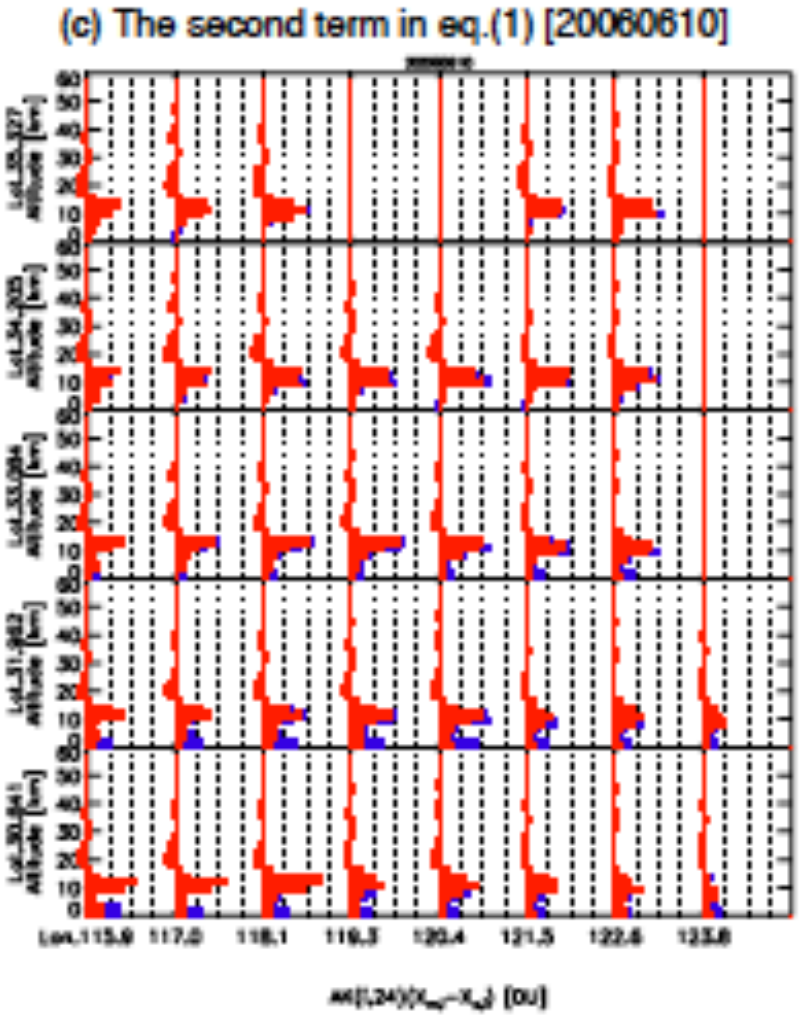

(e) Cross section 20060610 Lat. 34.205
(f) Cross section 20060620 Lat. 34.205
MRI CCM2
MRI CCM2
Altitude[km]
Longitude
1.0E+11
5.4E+11
9.8E+11
1.4E+12
1.9E+12
2.3E+12
MRI-CCM2 CNTL O_3 ad
(a)
(b)
Lat.35-37.5 Altitude [km]
20060610
20060620
O3 [DU]
18.0
16.5
15.0
13.5
12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0

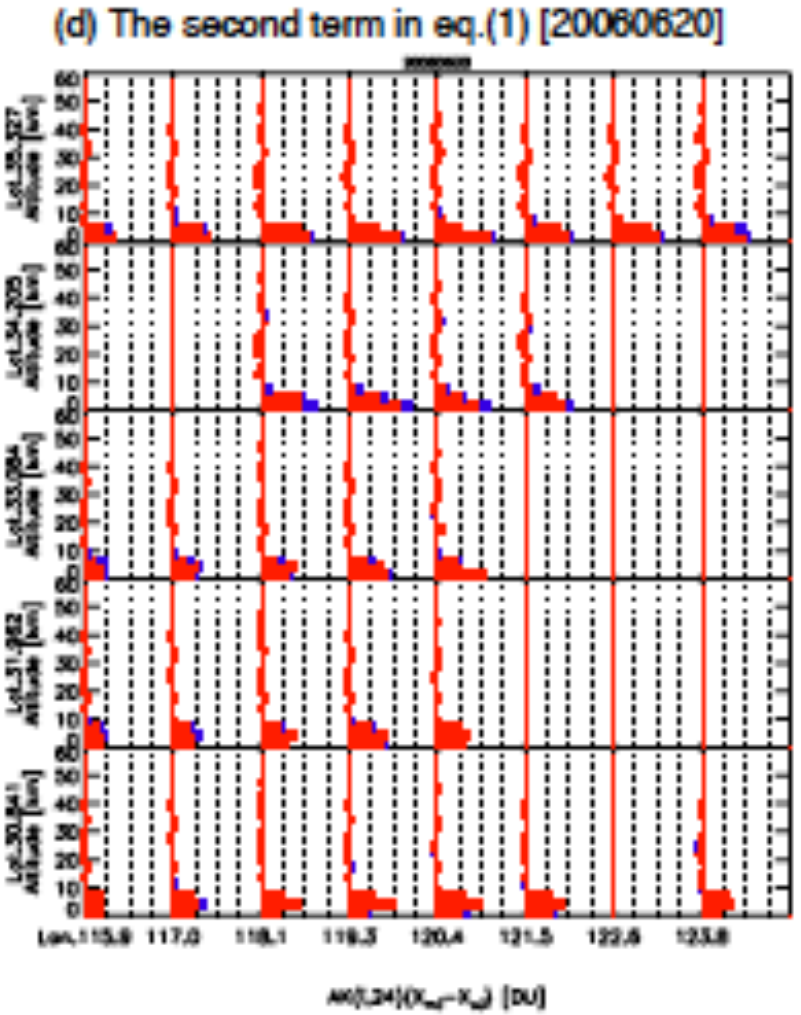
Contribution of UT/LS O_3 increase to the 24th layer O_3 Profile for each grid



Contribution of UT/LS O_3 increase to the 24th layer O_3

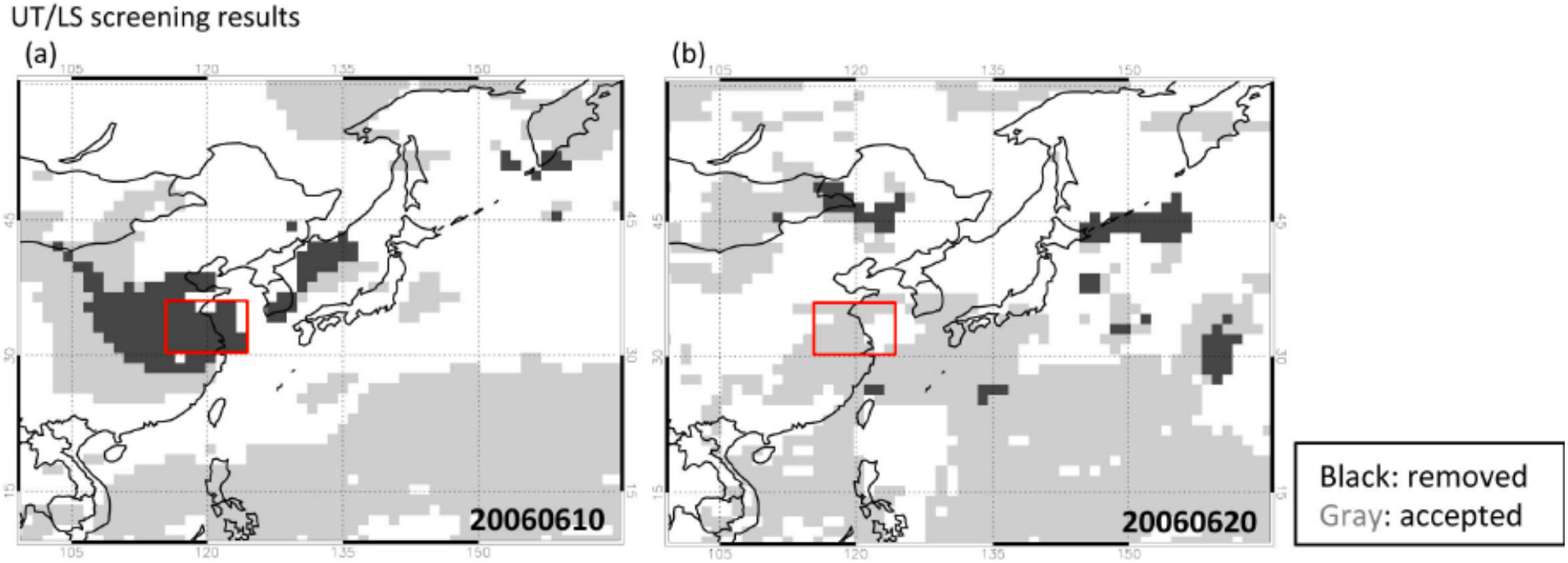
$$X'_{24} = X_{a,24} + \sum_{i=1}^{24} A(i,24)[X_{m,i} - X_{a,i}]$$





Grid Selection:

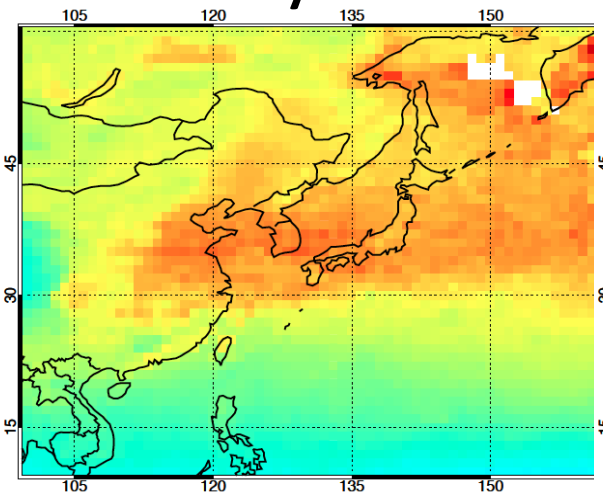
Remove the grids in which the effect of the UT/LS O_3 variability on the 24th-layer O_3 is larger than the threshold



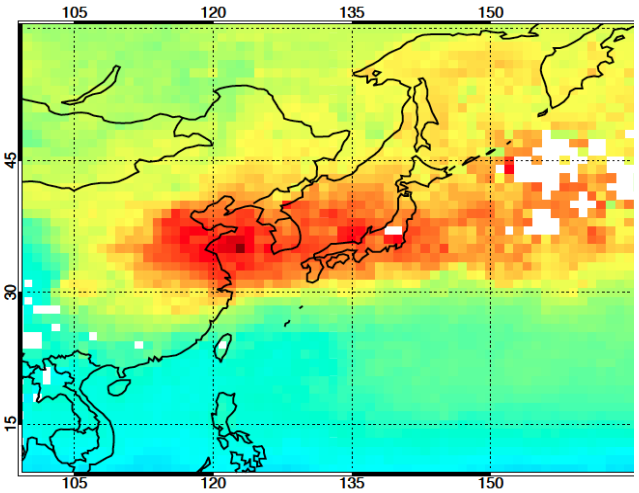
"Doubtful grids" were determined based on a model simulation, and those grids were removed from OMI analysis

After the screening
Monthly mean in 2006

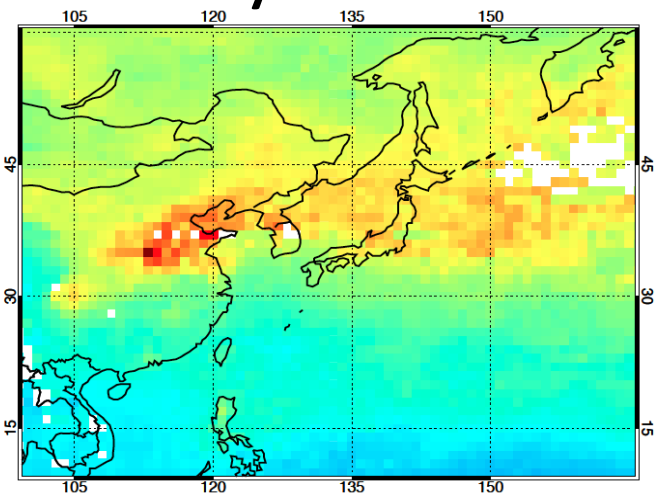
May



June



July



Even after the UT/LS screening, we were able to find a clear enhancement of lower tropospheric O3 over CEC in summer of 2006.

Comparison of OMI vs. MRI-CCM2

Table 1. Anthropogenic and biomass burning emission inventories

	Control run (CNTL)	Sensitivity study for open crop residue burning (OCRB)
Anthropogenic	MACCity (monthly)* (Lamarque et al. 2010; Garnier et al. 2011)	
Biomass burning	GFED ver.3 (monthly)*	GFED ver.3 + OCRB emission inventory developed by K. Yamaji**

*Monthly values were divided by 30 to convert them to daily values for calculations.

Emission inventory data for Open Crop Residue Burning (OCRB) have been updated by Kazuyo Yamaji (Yamaji et al. ACP, 2010) based on the scheme of Yan et al.(Atmos. Environ., 2006).

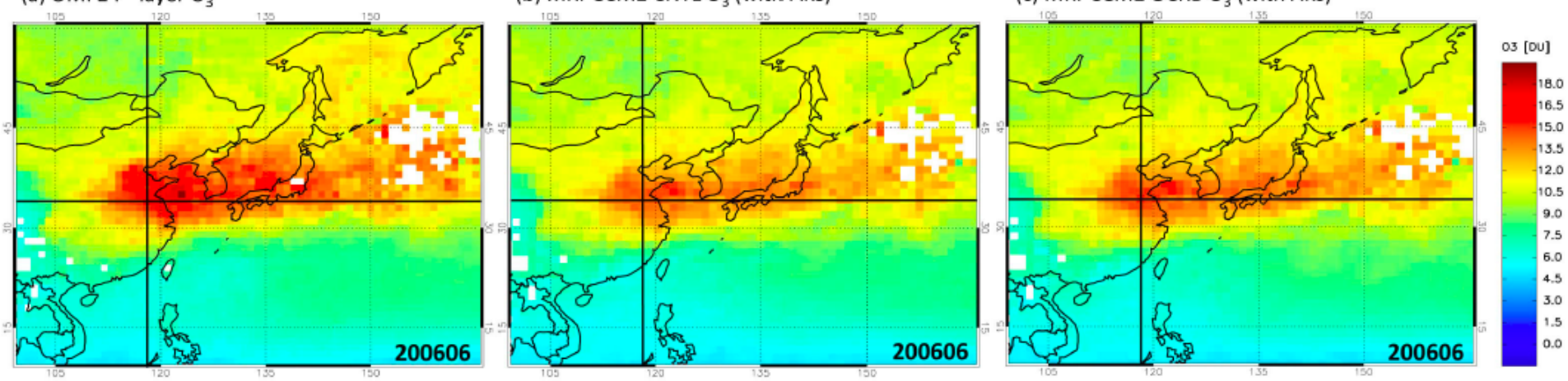
Comparison of OMI vs. MRI-CCM2

MRI-CCM2 O3 (adjusted to 24th Layer) with AKs

OMI 24th Layer

CNTL

OCRB sensitivity study



The observed O_3 enhancement over CEC in June 2006 was reproduced very well by the model simulations.

The effect of OCRB on O_3 does not seem to be significant, although it may be more significant when focusing on surface O_3.

Summary-1
Screening of the UT/LS effect

- We developed a scheme to eliminate the grids affected by UT/LS ozone enhancement.
- By applying the UT/LS screening, we were able to find a clear enhancement of lower tropospheric O_3 over CEC in June 2006 and confirmed the conclusion described by Hayashida et al. (2015).

Summary-2
Comparison of model and observation

- "June-maximum" of ozone over CEC can be interpreted almost by anthropogenic emissions and active photochemistry in June.
- The effect of OCRB on ozone enhancement does not seem to be significant, although it may be more significant when focusing on ozone in the planetary boundary layer.
- Simulation by a regional model with a finer resolution is now under investigation.

Suggestions to GEMS

- GEMS has a potential to derive ozone profiles as OMI.
- The UT/LS screening is essentially important to estimate the lower tropospheric ozone quantitatively.
- The screening method should be simpler for processing all data.
- Application of only meteorological data (not model simulations) would be better.

Thank you for your attention

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Land-Atmospheric Interactions in Asia

Book Series: Springer Remote Sensing/Photogrammetry

Editors: Krishna Prasad Vadrevu, Toshimasa Ohara, Chris Justice

Forthcoming, Summer 2016

▸Maximizes reader insights into the quantification of land cover/land use changes (LCLUC) and greenhouse gas emissions in Asia.

This study has been accepted as Hayashida et al. "Study of lower tropospheric ozone over central and eastern China: Comparison of satellite observation with model simulation". Land-Atmospheric Interactions in Asia, Springer (to be published soon).