Modeling of Climate Change and Dust over China by RegCM3

Gao, X.J. et al.

Workshop on Aerosol-Climate Interactions:
Mechanisms, Monitoring, and Impacts in Tropical Regions
11 - 15 February 2008
Hurghada, Egypt

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I. Reduction of Future Monsoon Precipitation over China: Comparison between a high resolution RCM Simulation and the driving GCM

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Workshop on Aerosol-Climate Interactions, February, 2008, Hurghada

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The ICTP RegCM

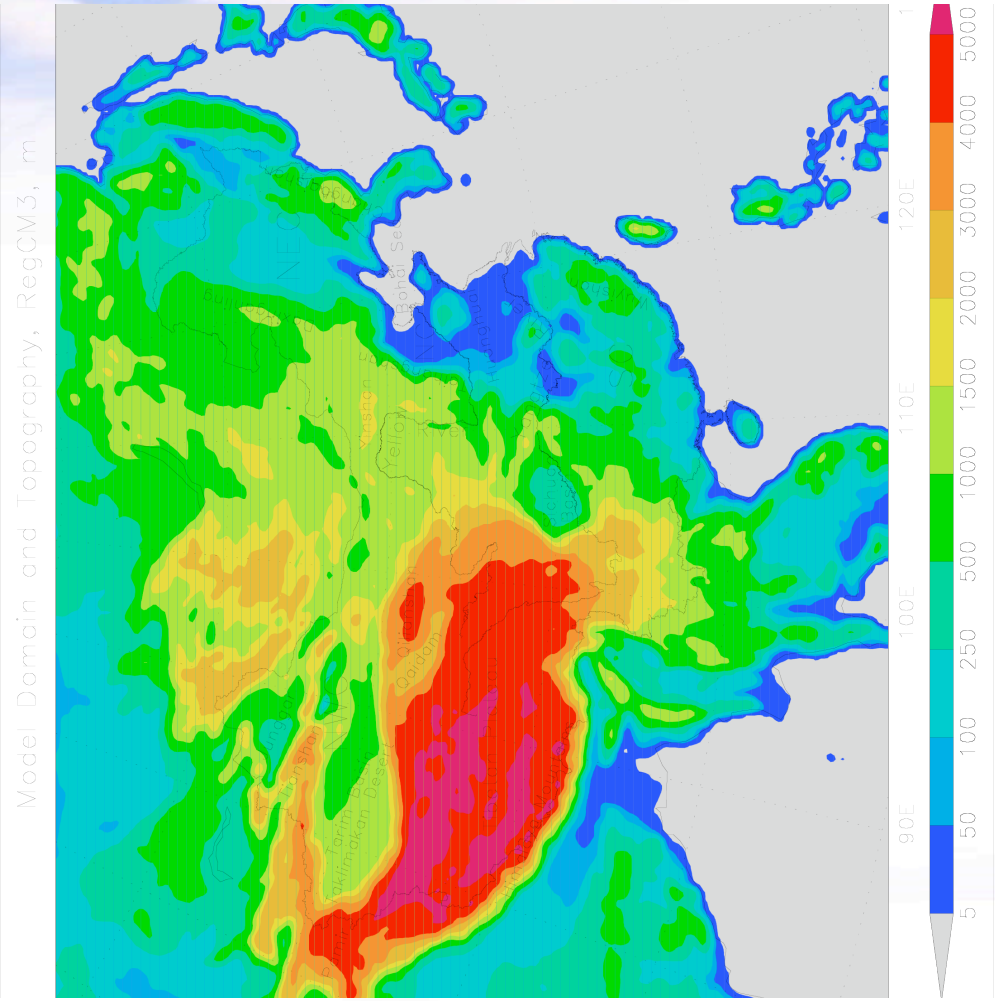
20 km resolution, L18

Forcing fields from NCAR/NASA FvGCM (1×1.25°)

Reference simulation (1961-1990)

A2 scenario simulations (2071-2100)

Focused on the monsoon season: May-September



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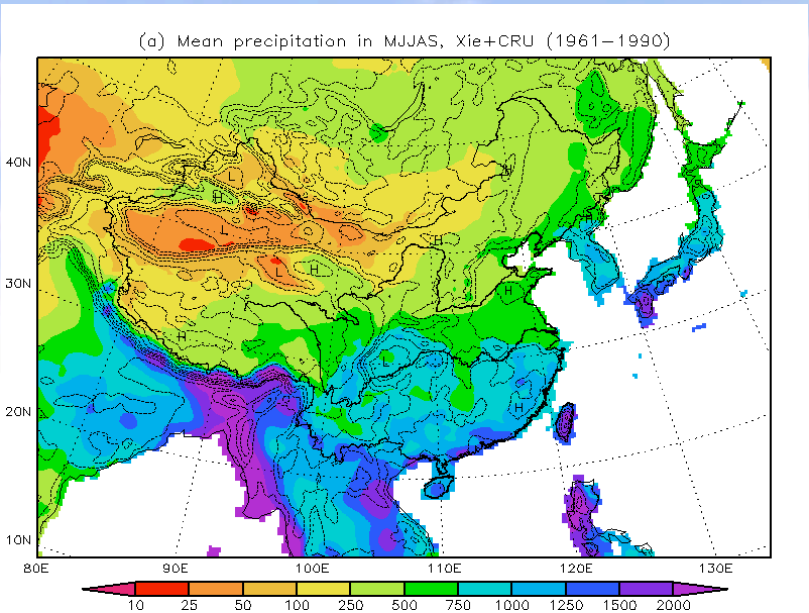

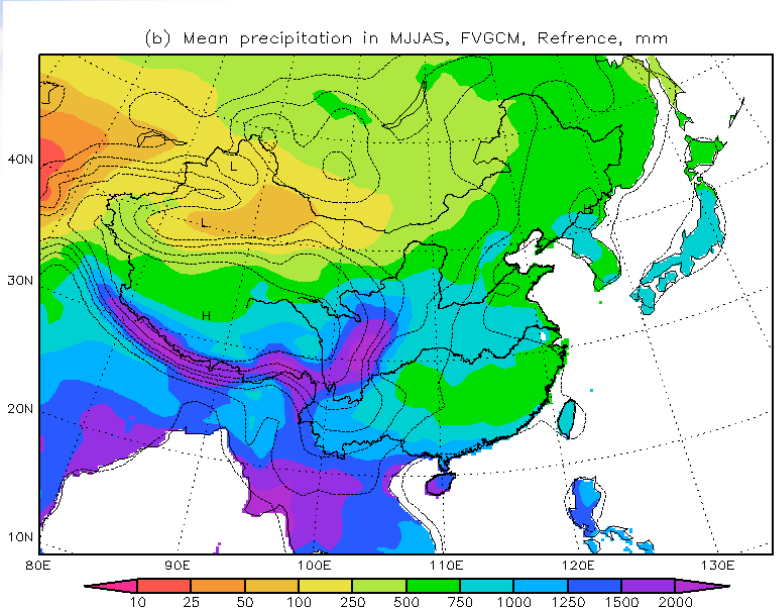

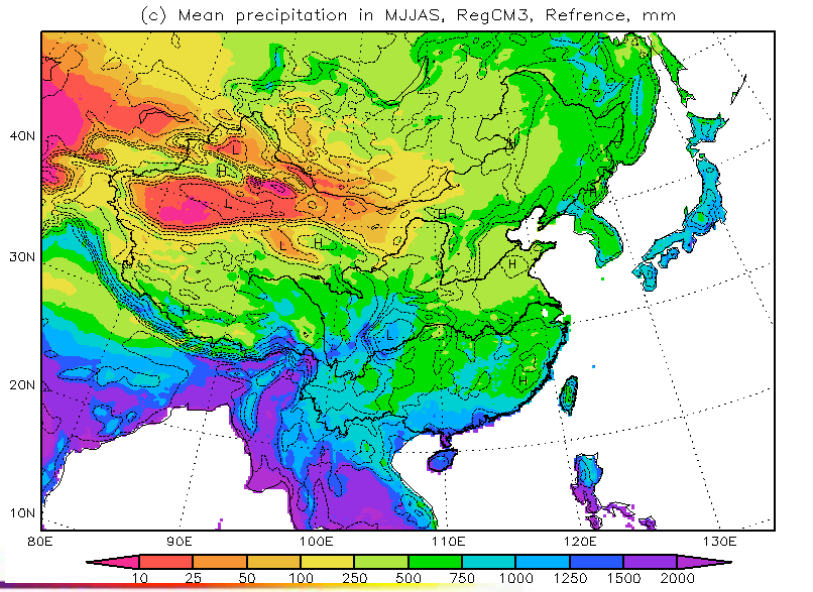

Validation of the present day monsoon precipitation (MJJAS) simulation

OBS

FvGCM

RegCM3

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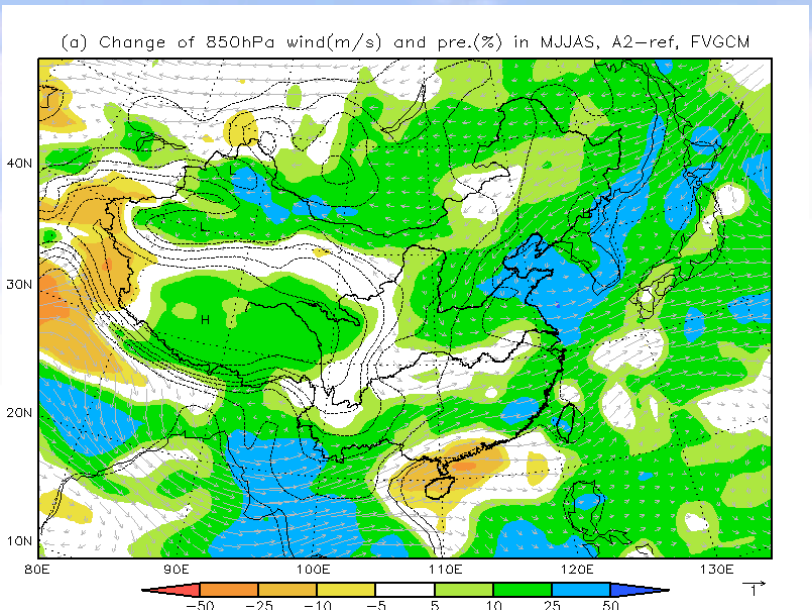

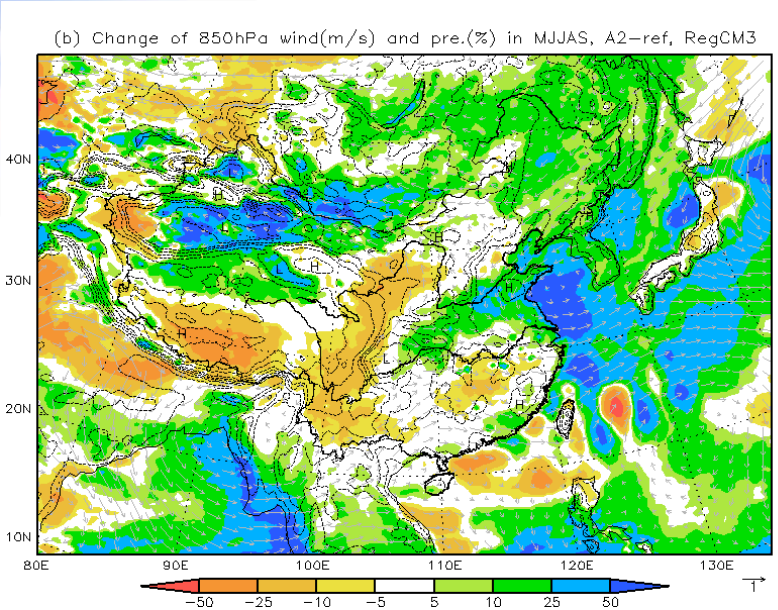

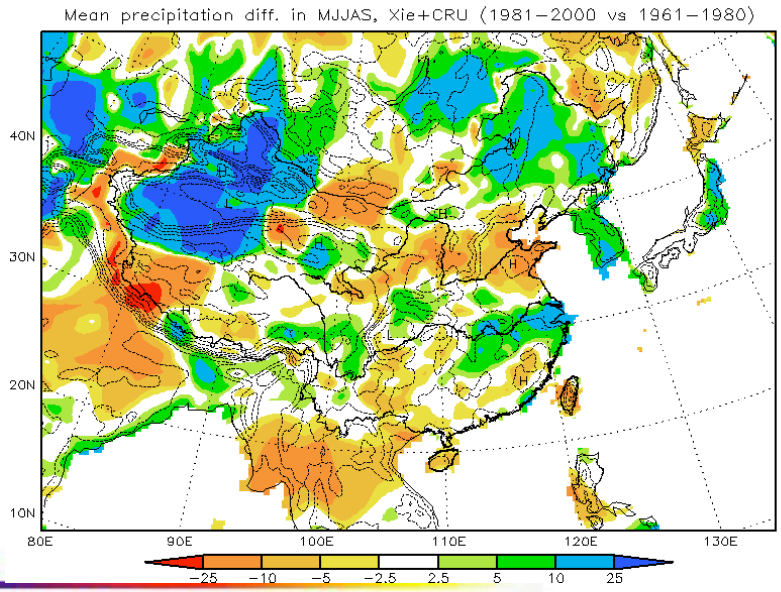

Simulated future changes by the FvGCM and RegCM, and observed changes in the late decades

FvGCM **RegCM3**

Observation (1981-2000 vs 1961-80)

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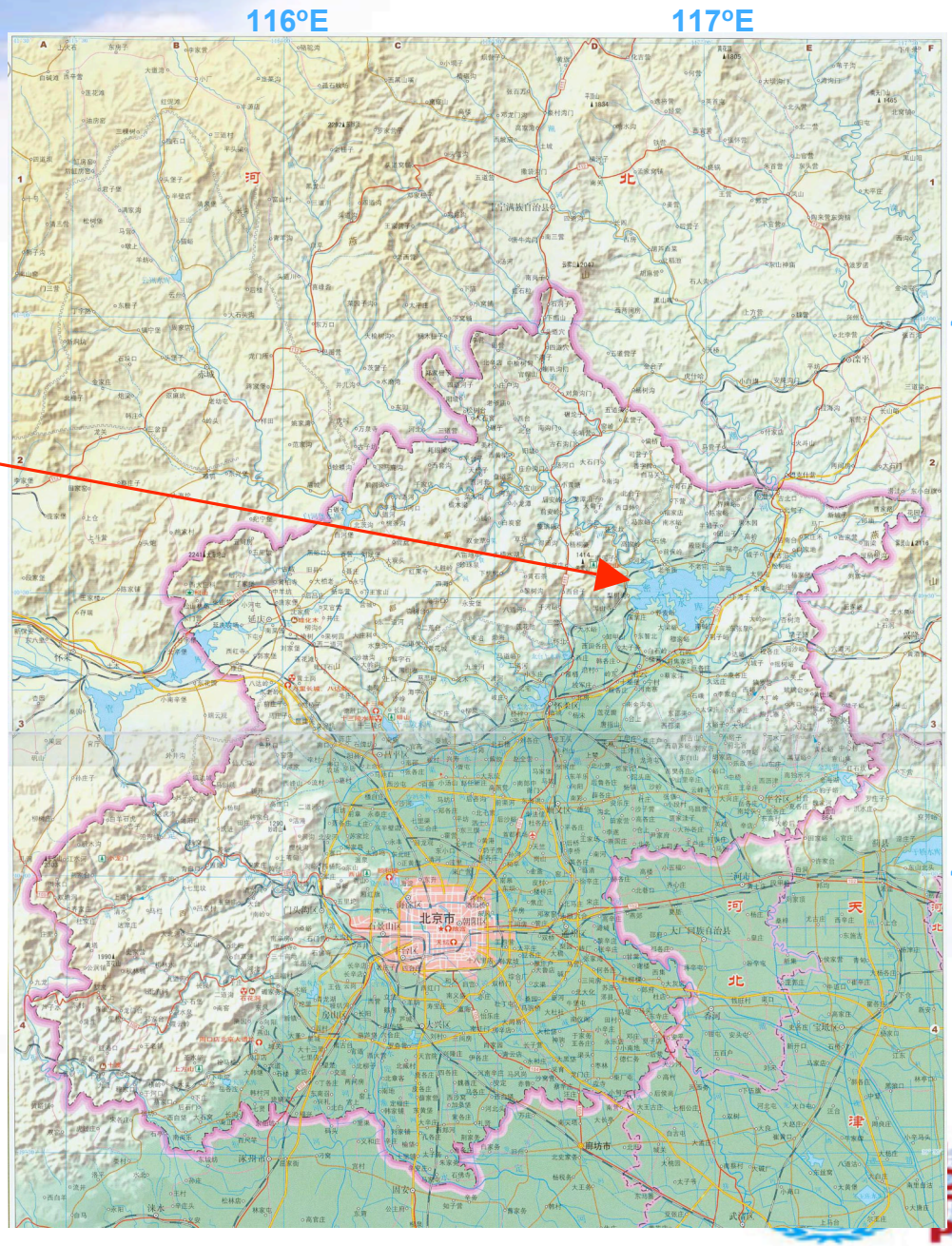
Possible study in climate change and changes of water resources:

Miyun Reservoir,

The major water supplier for Beijing, watershed < 150 km*100 km (1.5°*1°)

Beijing suffered from water shortage in the late decades



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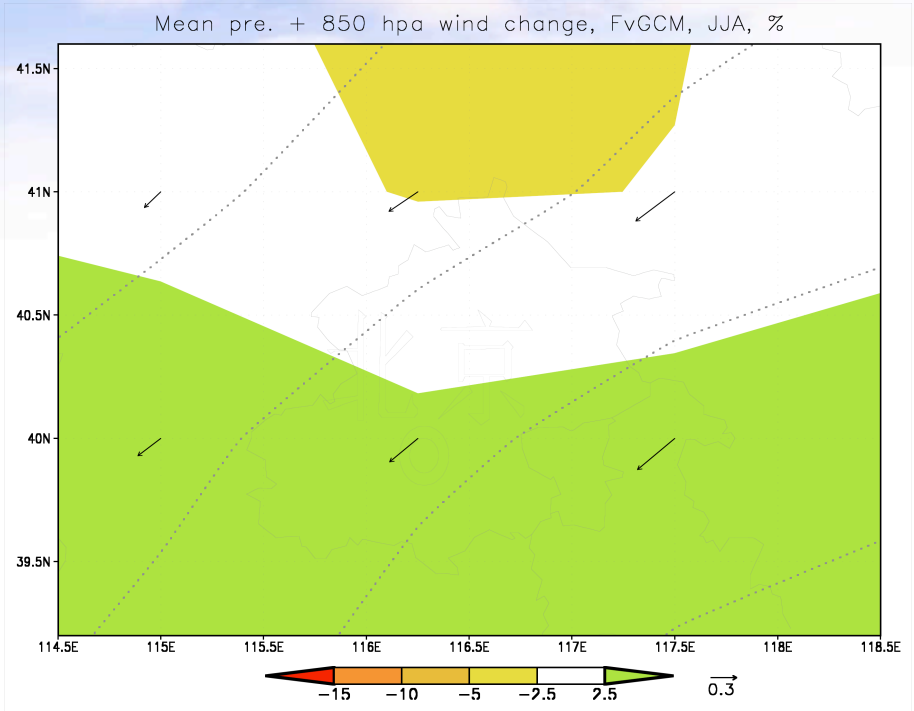

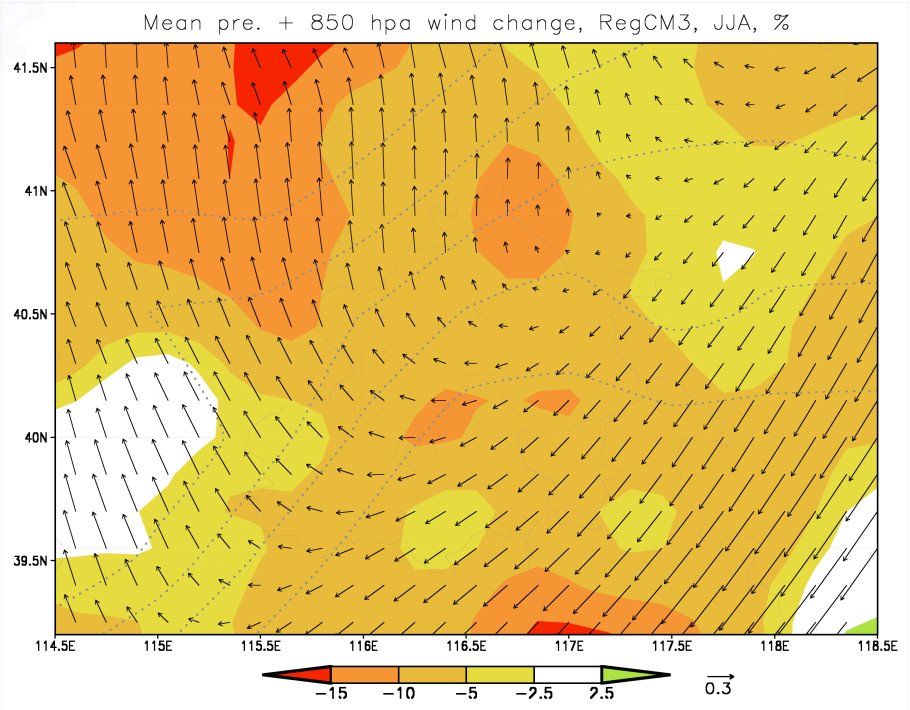

Precipitation change in JJA in Beijing by FvGCM and RegCM, %

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Conclusions and discussions

1. Resolution plays a very important role in the simulation of East Asia monsoon precipitation.

2. RegCM simulates some significantly different change patterns compared to the driving FvGCM.

3. The FvGCM projected a prevailing increase of monsoon precipitation, while the RegCM projected extended areas of decreased precipitation.

4. Importance of resolution in climate change and impact studies

II. Modeling of Dust on East Asia Emissions and Impacts

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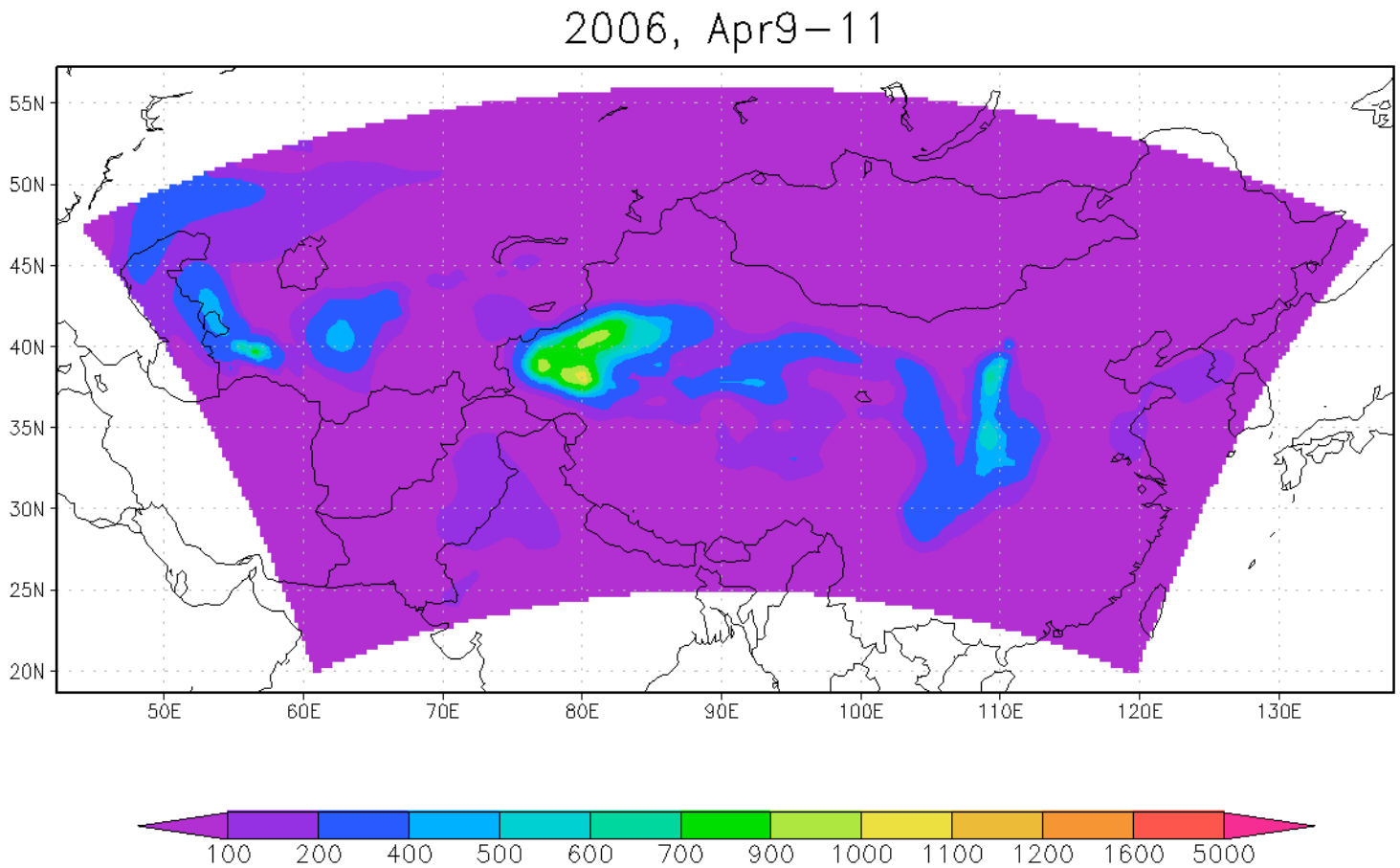
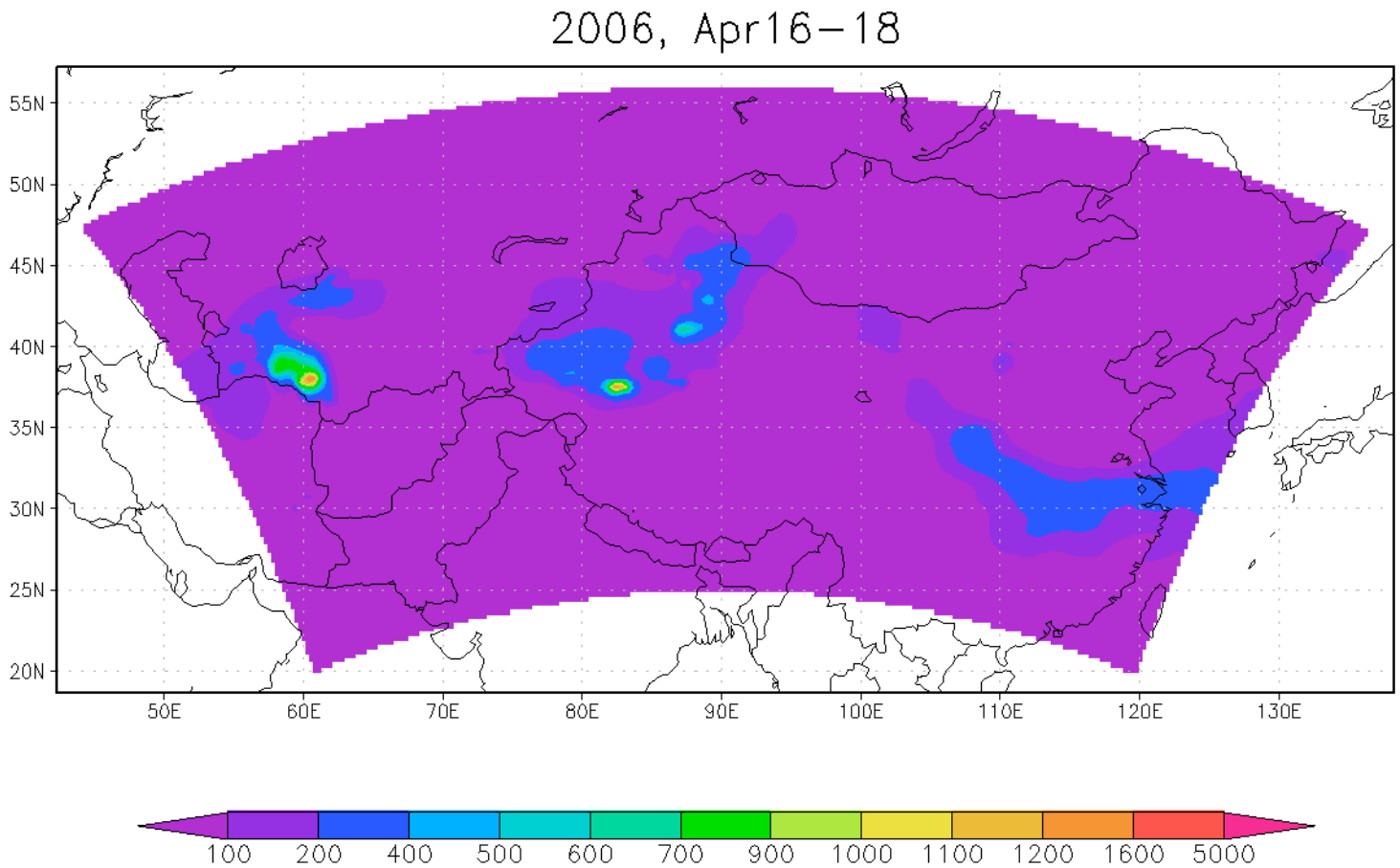
Case Study, April 9-11, 2006



Strongest in the latest 20 years over some areas

Case Study, April 16-18, 2006



Dry deposition of dust over 330,000T in Beijing

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•Experimental Design:

•The ICTP RegCM

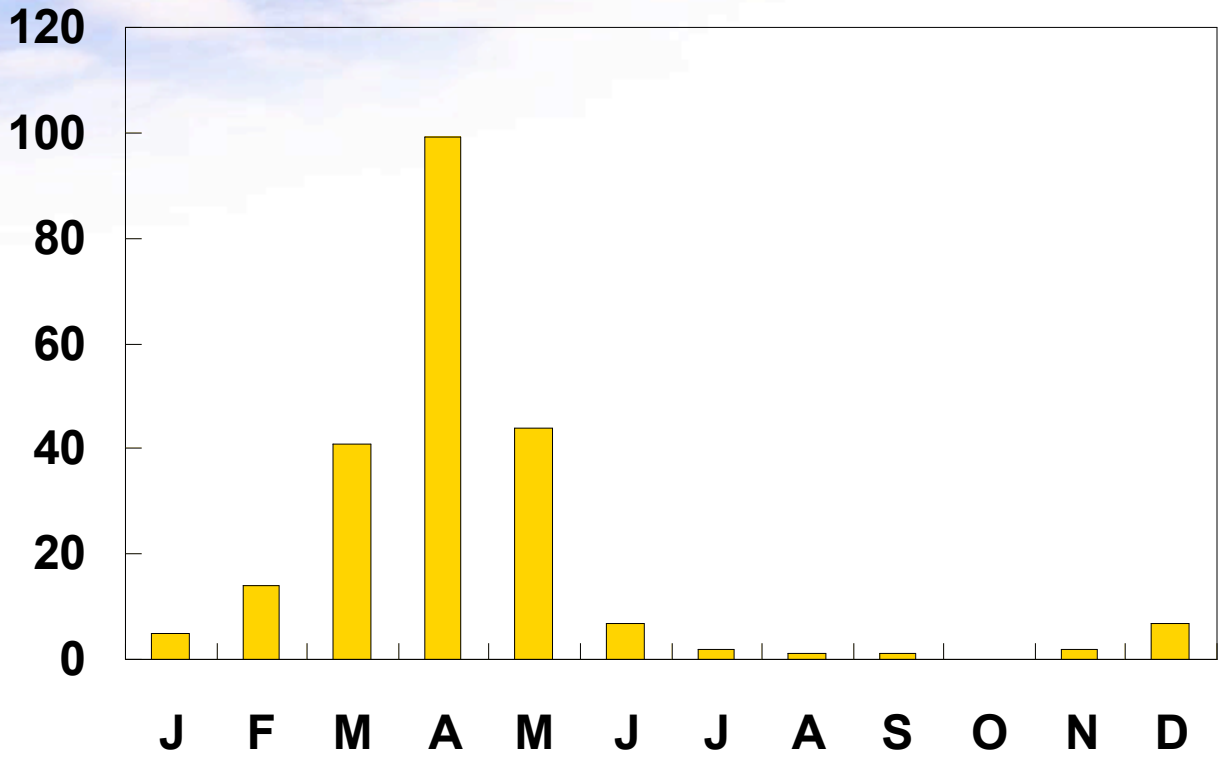
•Exp.1: without the radiative effects of dust aerosols, model validation

•Exp.2: with the radiative effects of dust, climate feedback of dust aerosols

•November 1 to June 1 of the following year

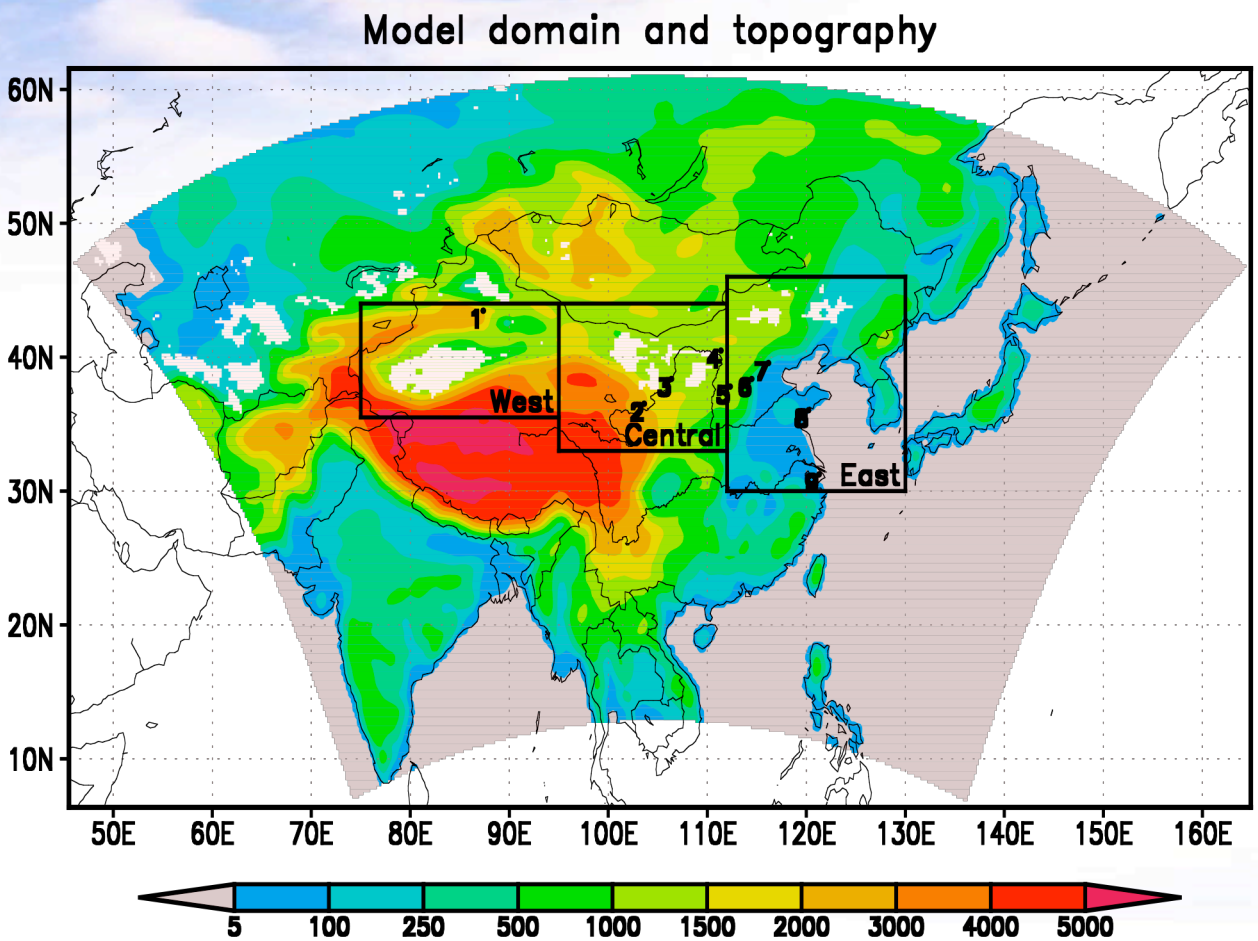
•November, December and January are used to initialize the model, the analysis are focused on February to May (FMAM)

- 1997 to 2006, 10 years simulation for each experiment
- ICBC: NCAR/NCEP Reanalysis
- Soil texture: USDA textural classification + extra dust sources in China
- Convection: Grell, Large-scale: SUBEX, Land surface: BATS, PBL: Hotslag
- 50km resolution, 18 levels



Observed number of dust events over China

FMAM accounts for ~90% of the annual total



White color is for the model source regions
9 stations, three effective sub-regions

Exp. 1 Model validation over East Asia

Without the radiative effects of dust aerosols

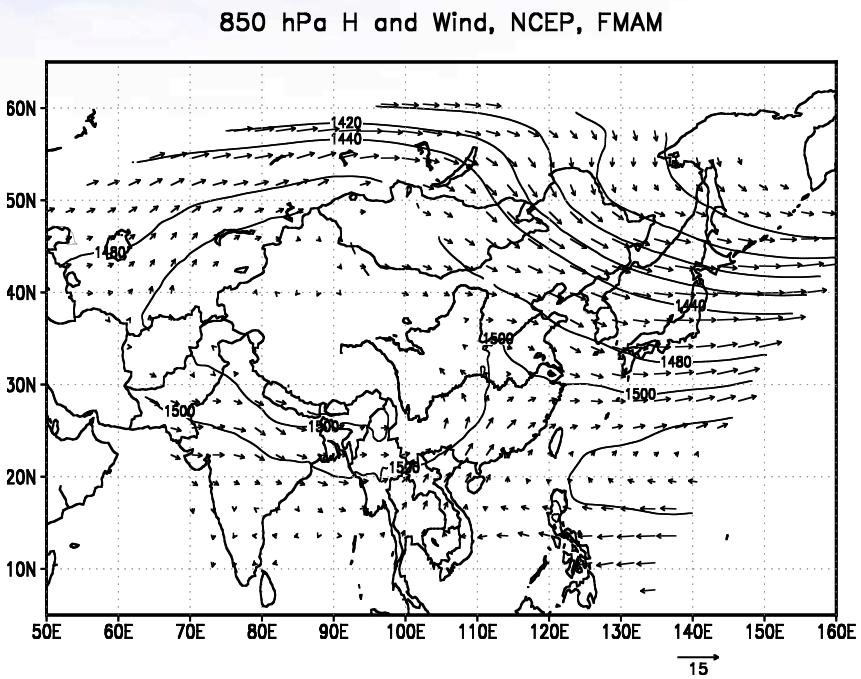
The emission processes follow Marticorena et al. (1995) and Alfaro et al. (2001)

Transportation process according to the tracer transport equation in Solmon et al. (2006)

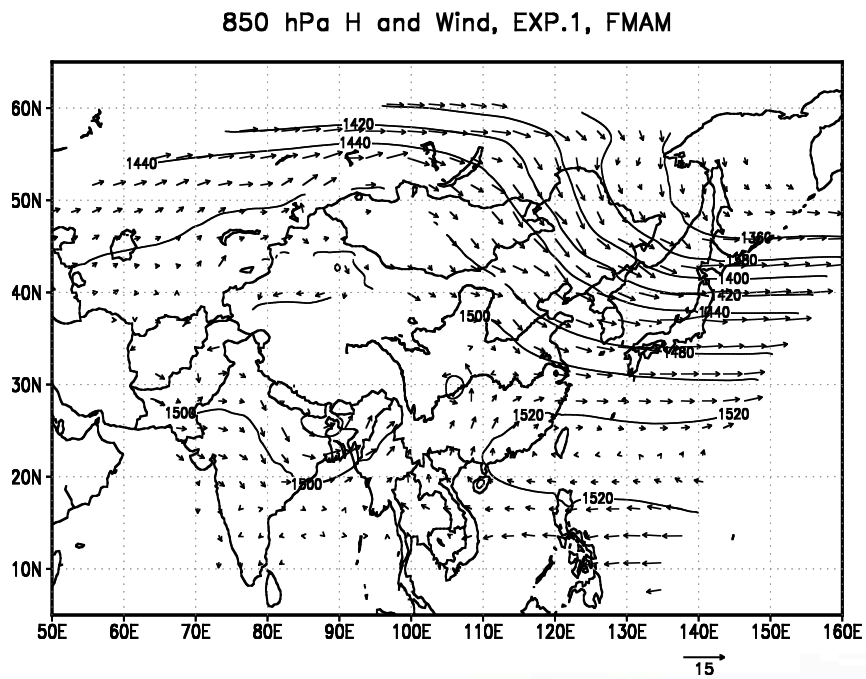
Wet deposition follows Giorgi (1989)

Gravitational settling term and dry deposition scheme are developed by Zakey et al. (2006)

850 hPa height and wind

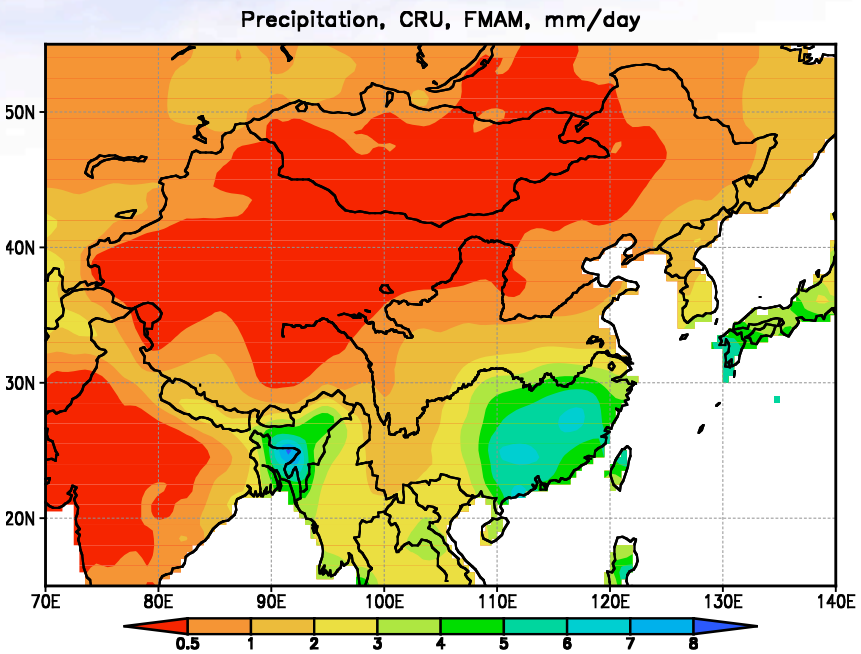


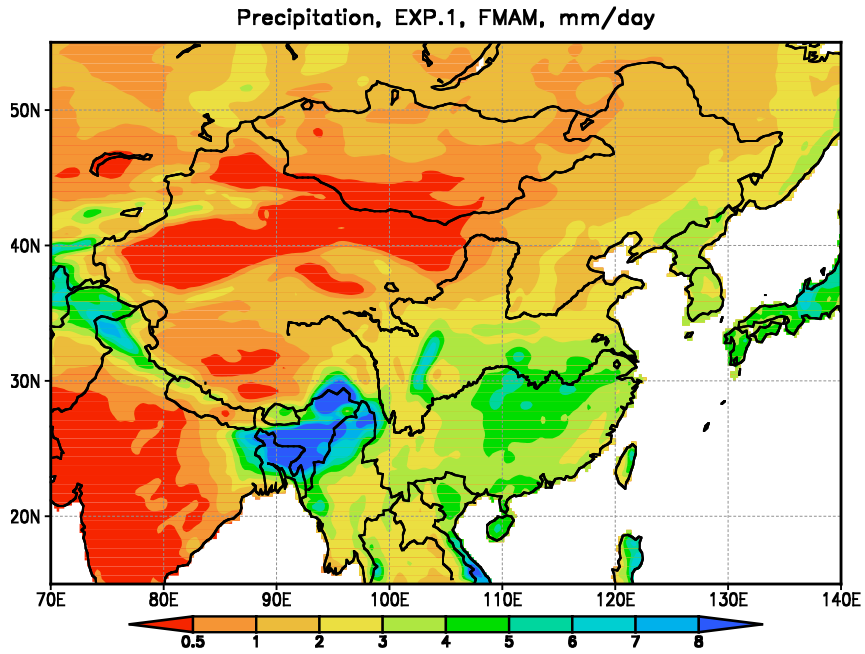
Re-analysis



Simulation

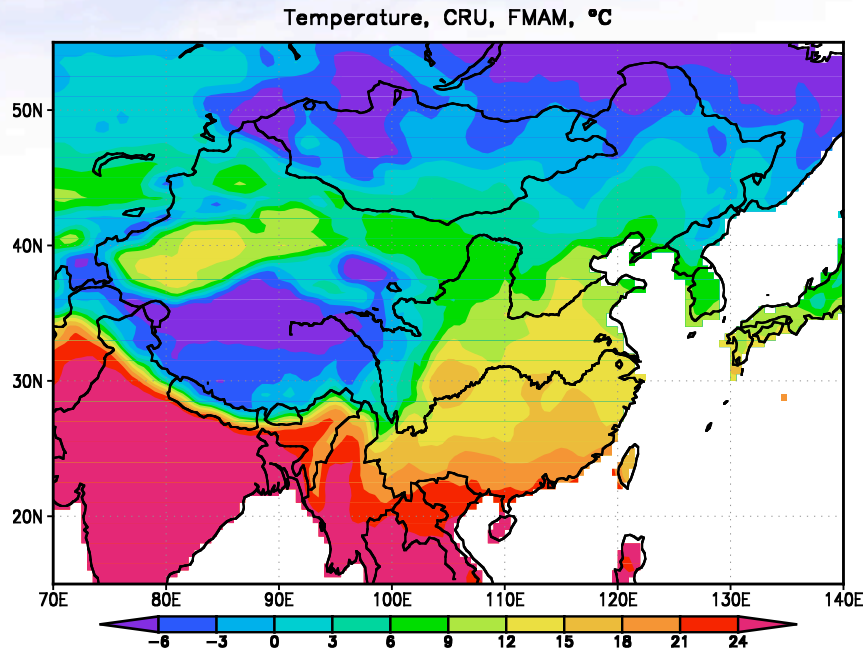
Precipitation

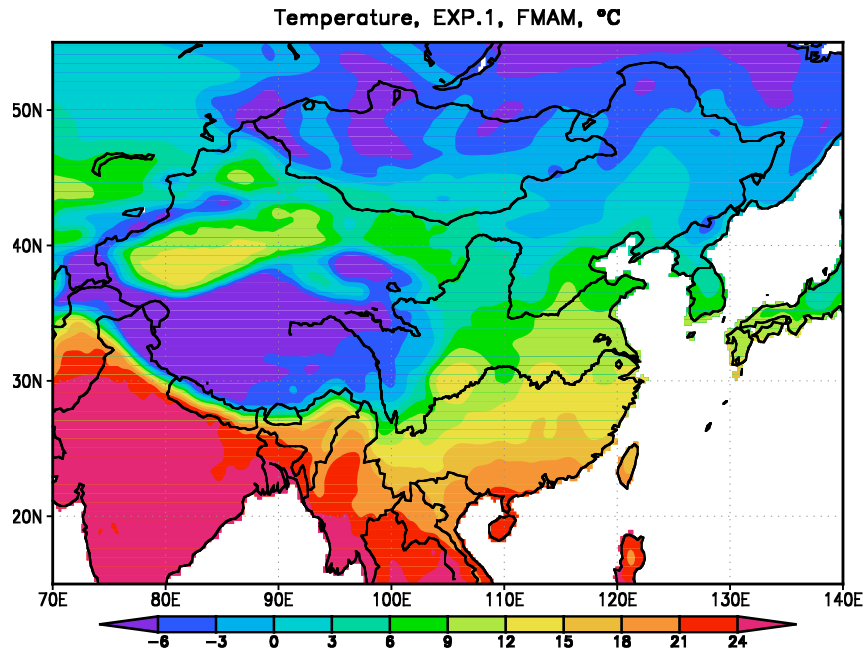




Observation **Simulation**

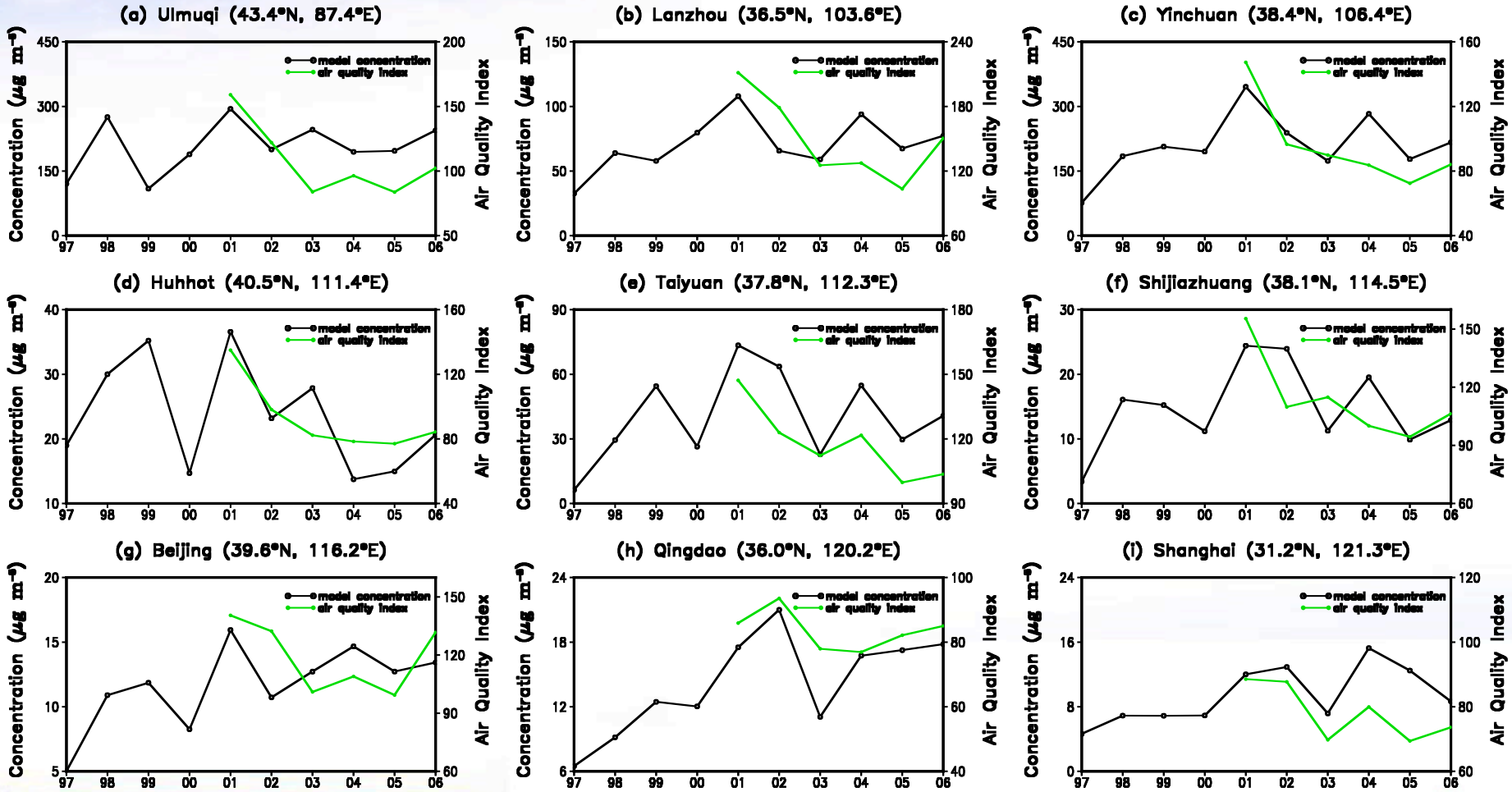
Temperature





Observation
Simulation

Simulated near surface concentration and observed air quality index at 9 selected stations



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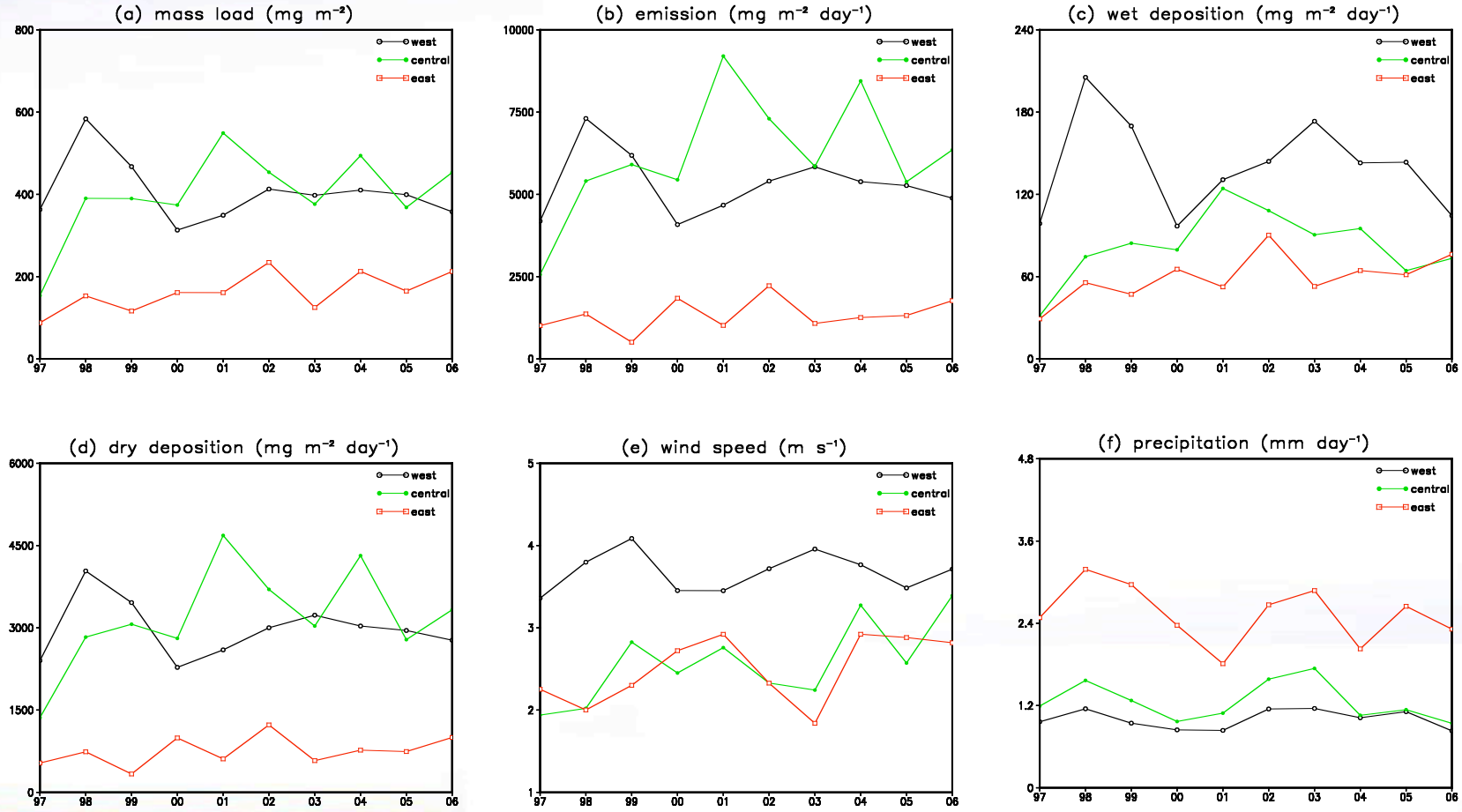
Simulated annual averaged mass load, emission, wet deposition, dry deposition, wind speed and precipitation for the three sub-regions



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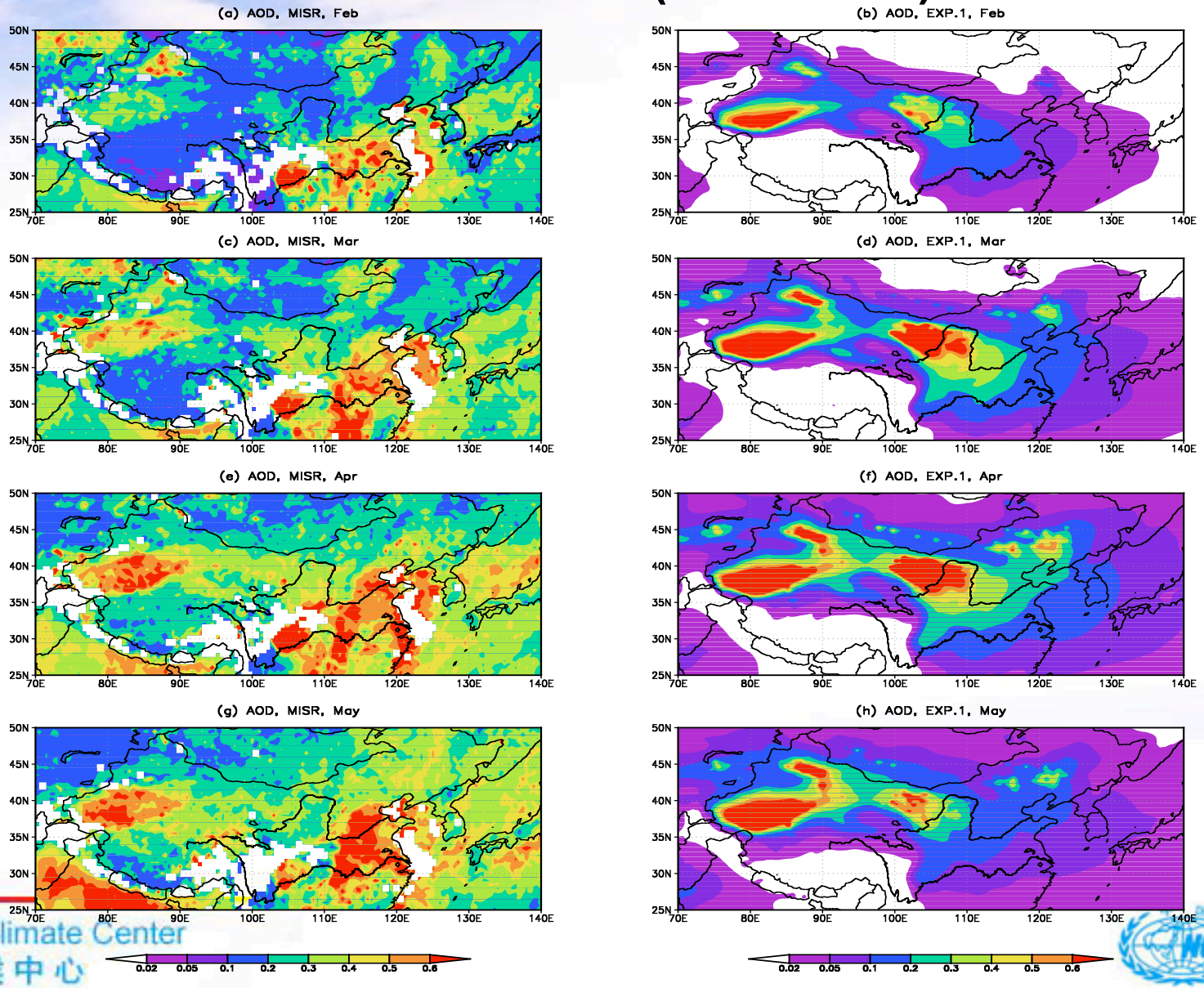
Monthly averaged AOD from MISR (550nm) (2001-2006) and simulation (1997-2006)



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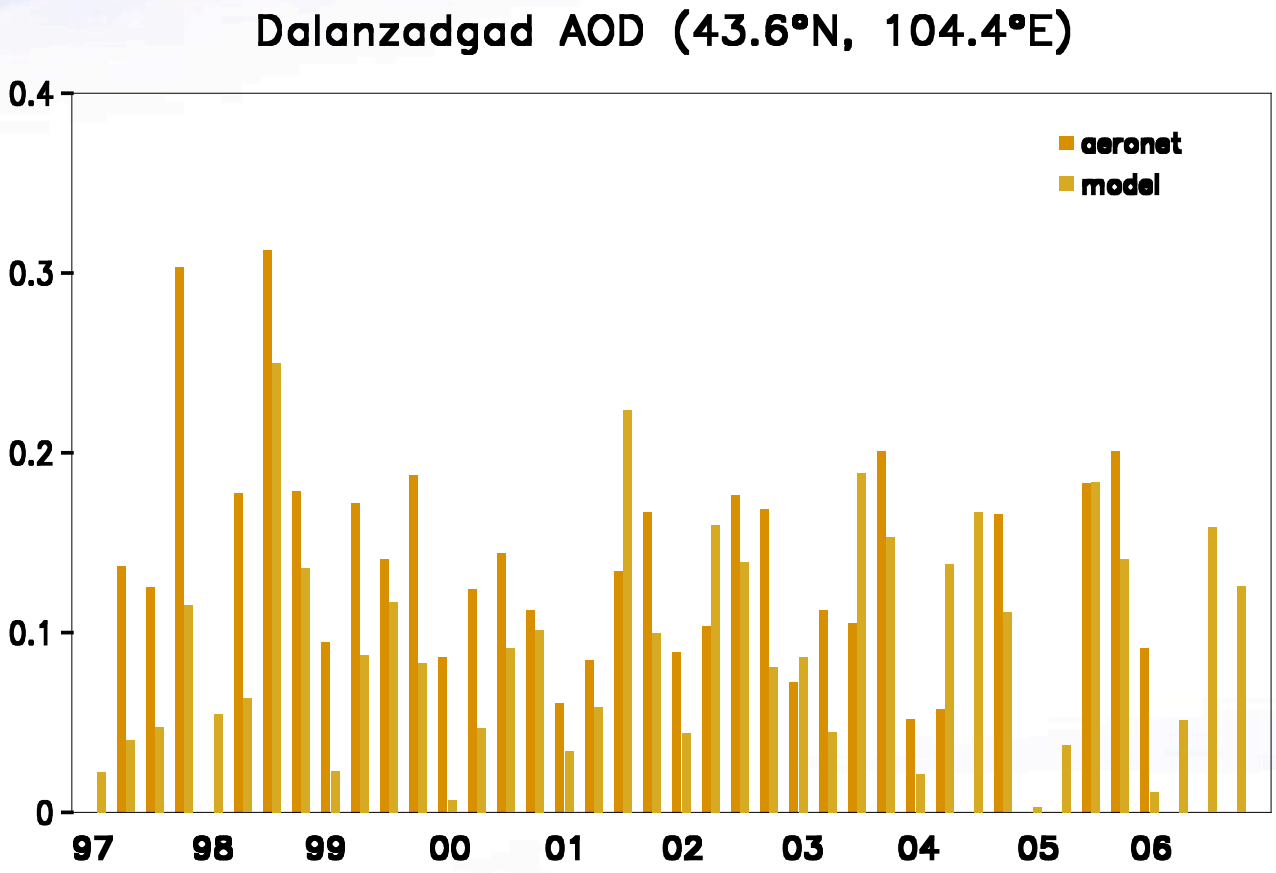
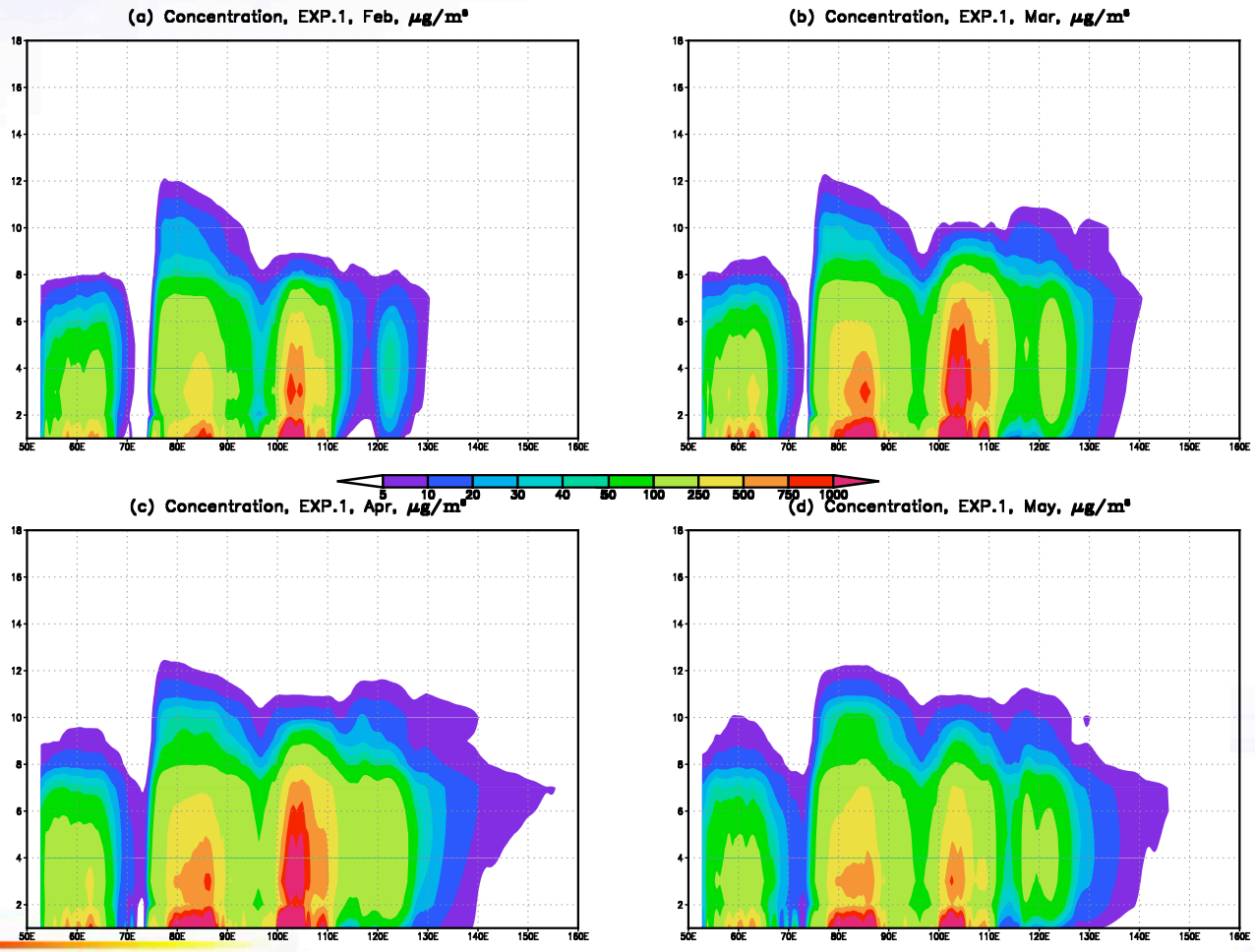
Monthly averaged optical depth from AERONET and simulation at Dalanzadgad (500nm)

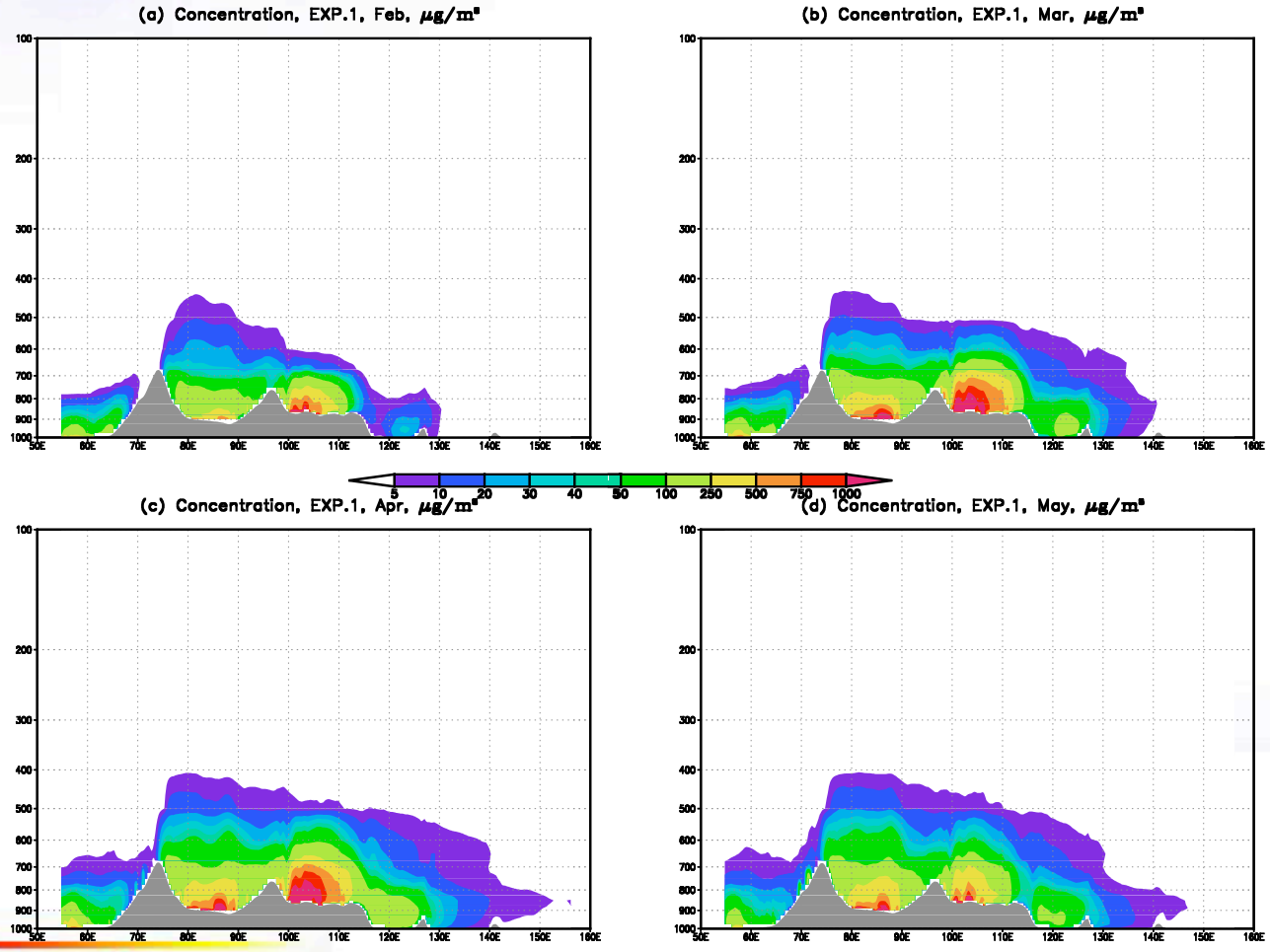


correlation coefficient: 0.55, 99% significant

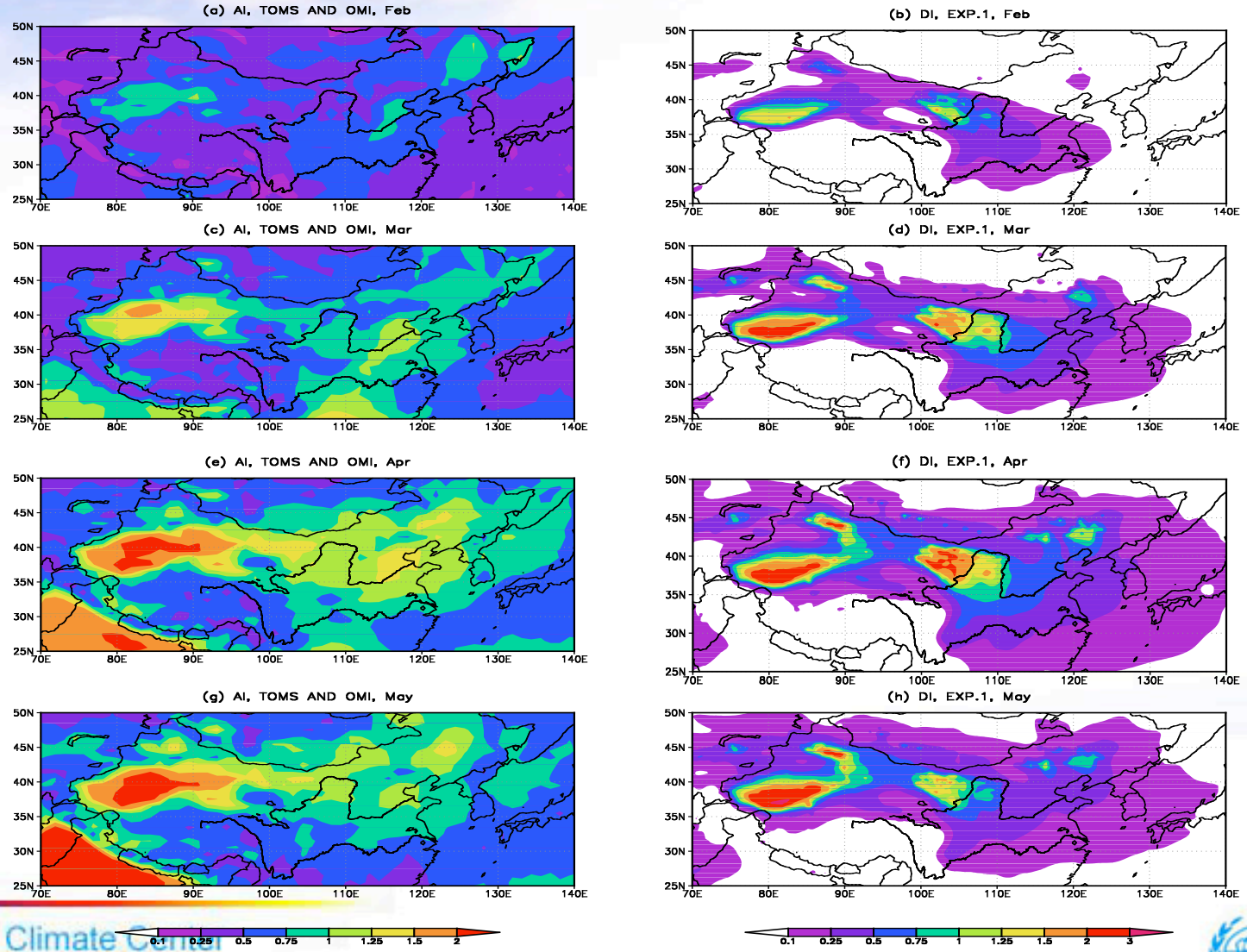
Simulated longitude-height cross section of dust concentration (38-42°N) (18 sigma levels)



Simulated longitude-height cross section of dust concentration (p levels)



Observation of monthly averaged AI from TOMS (380nm) and OMI and simulation of DI for 1997-2006



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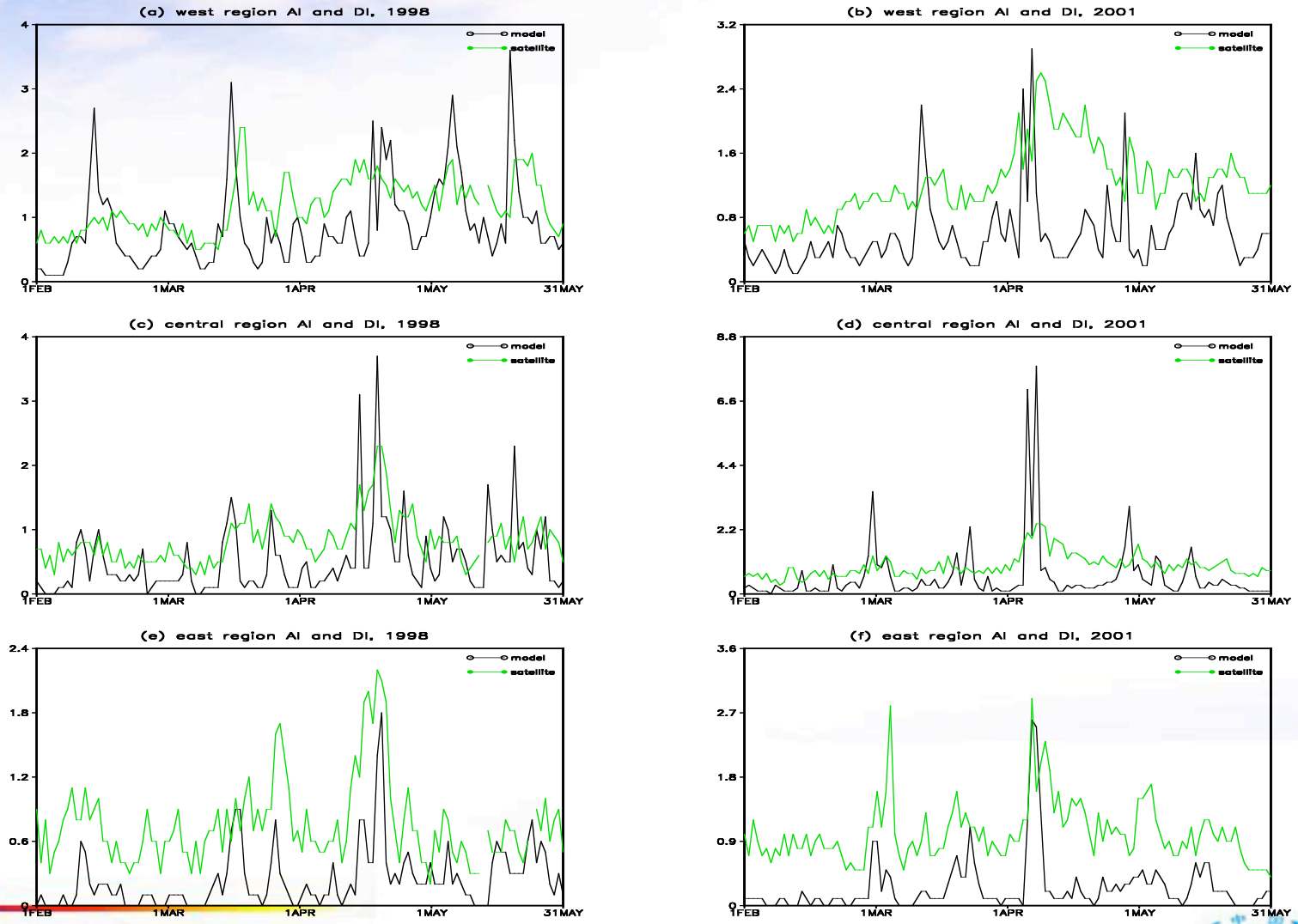
Correlation coefficient between the daily TOMS AI and modeled DI in FMAM

	1997	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*ave*
WEST	0.09	0.47	0.21	0.59	0.28	0.48	0.30	0.48	0.47	0.32	0.34
CENTRAL	-0.22	0.53	0.16	0.42	0.51	0.20	0.19	-0.06	0.17	0.42	0.27
EAST	0.04	0.56	0.25	0.60	0.52	0.54	0.38	0.19	0.51	0.53	0.40

The red color indicates correlation coefficient significant at the 99% (0.2244) confidence level.

Daily AI from satellites and DI from simulation over the three sub-regions in 1998 and 2001



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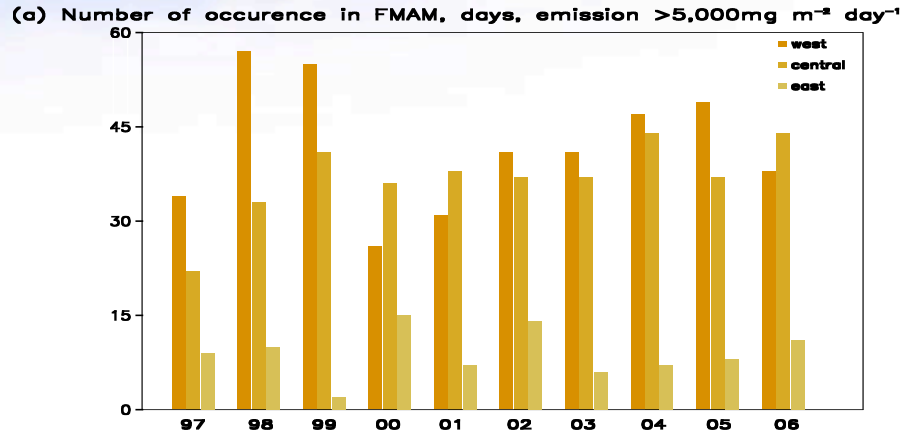
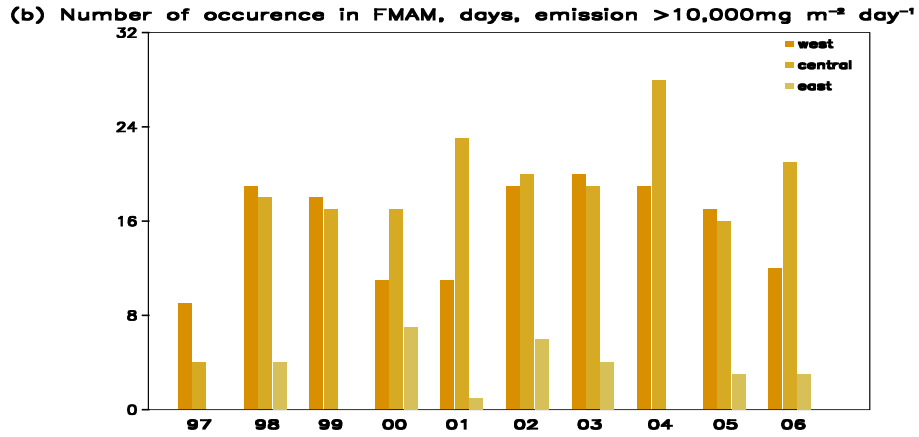
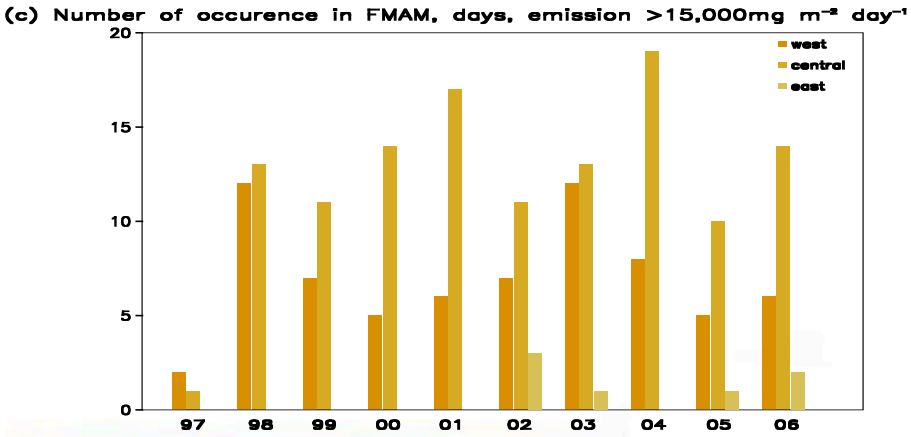
Number of the occurrence in the three sub-regions, as defined by the different emission thresholds







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Results:

RegCM reproduces the basic climatology.

Dust model performs reasonably well in simulating the spatial distribution, intra-seasonal and multi-year mean variation of AOD, DI and near surface concentrations.

Longitude-height cross section of the dust concentrations confirms the dust long distances mobilizations, although the dust lifting process is relatively weak.

The west region deserts are the most frequent sources of dust storms with lower emission thresholds and the central deserts are the most frequent sources if with higher emission thresholds.

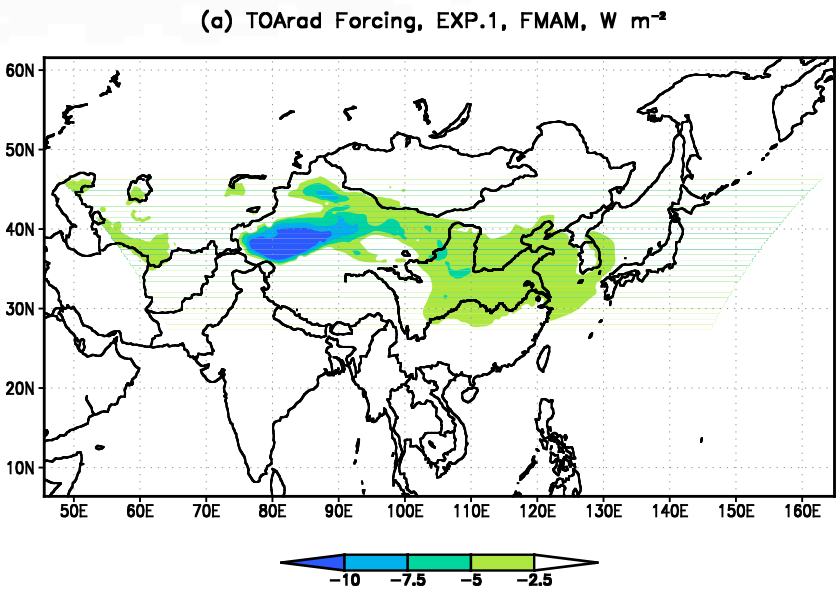
Overestimate of dust aerosol over the source regions and an underestimate away from these regions.

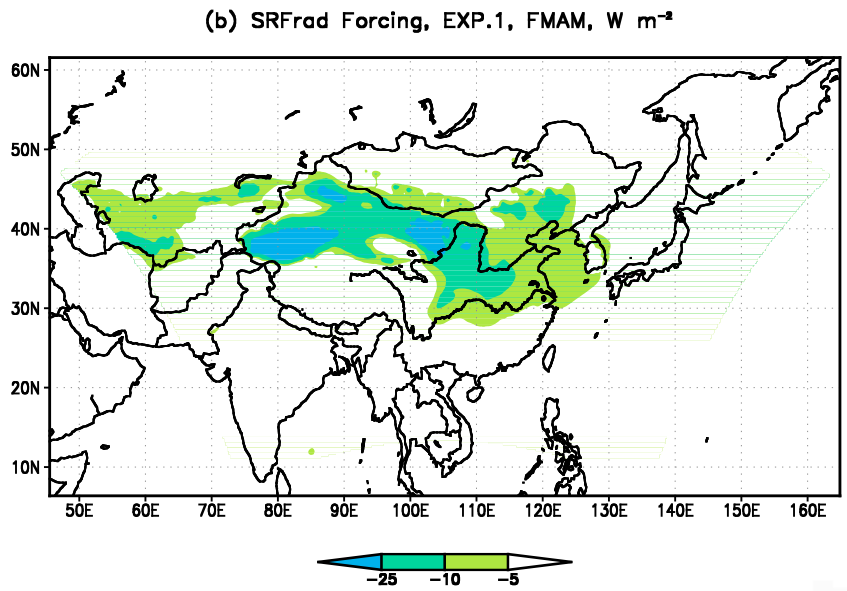
Exp. 2 Simulation of Climate feedback of dust aerosols over East Asia

The radiative effects of dust aerosols are included

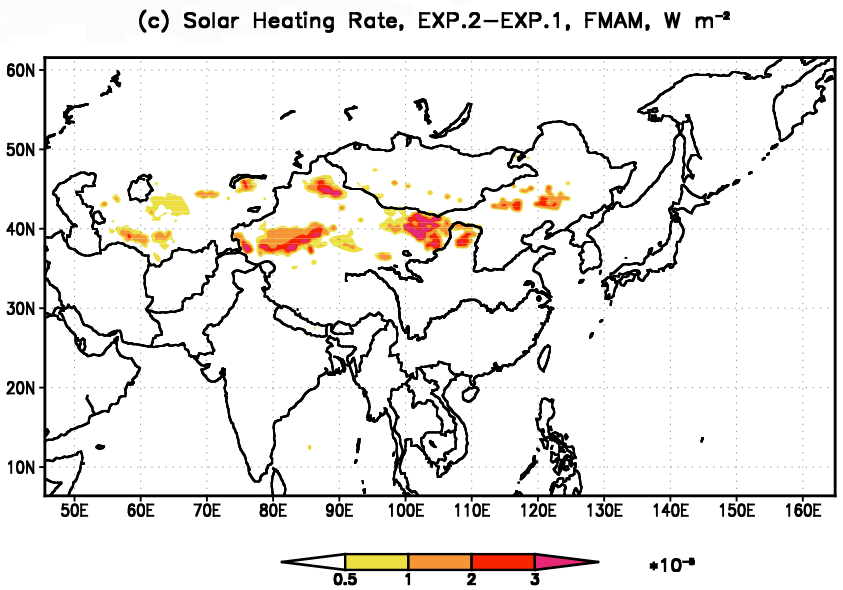
Exp.2 - Exp.1

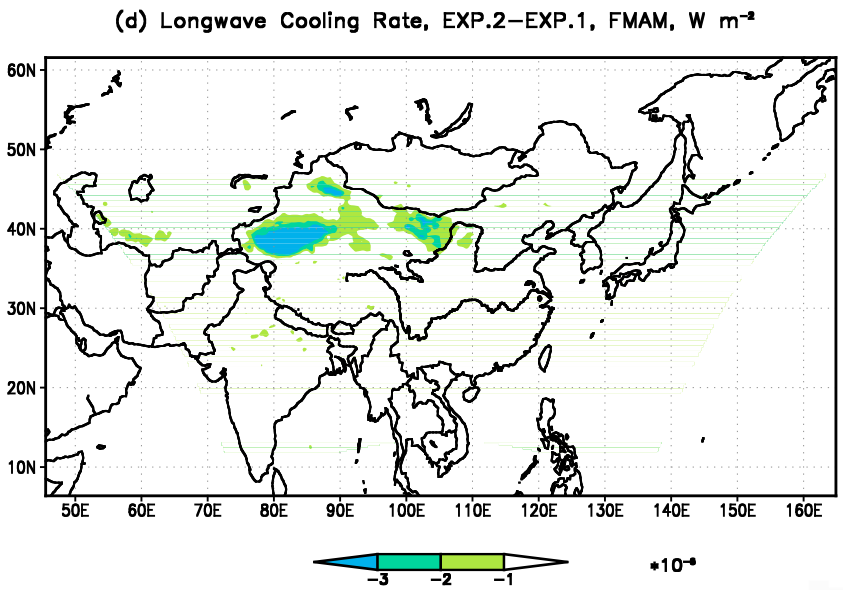
Effects on TOA rad and SRF rad



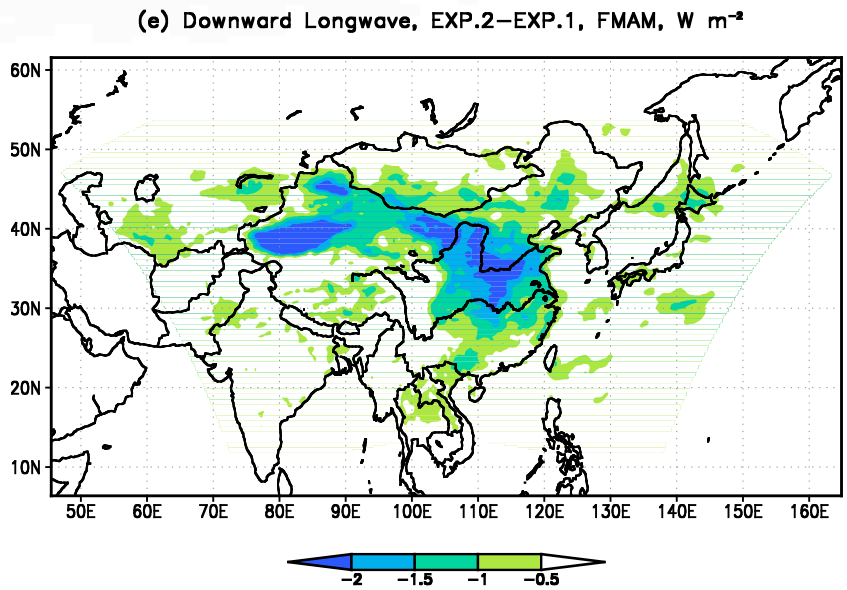


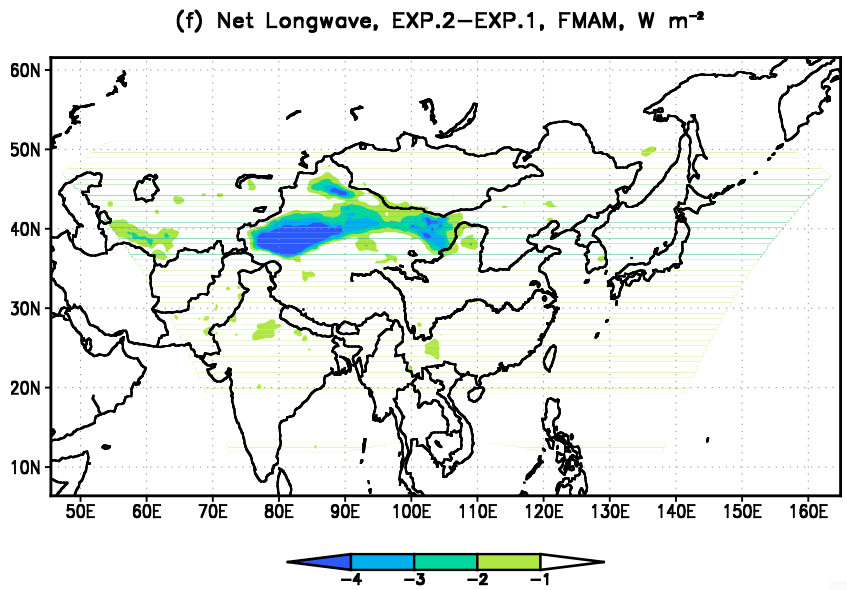
Effects on solar heating and LW cooling



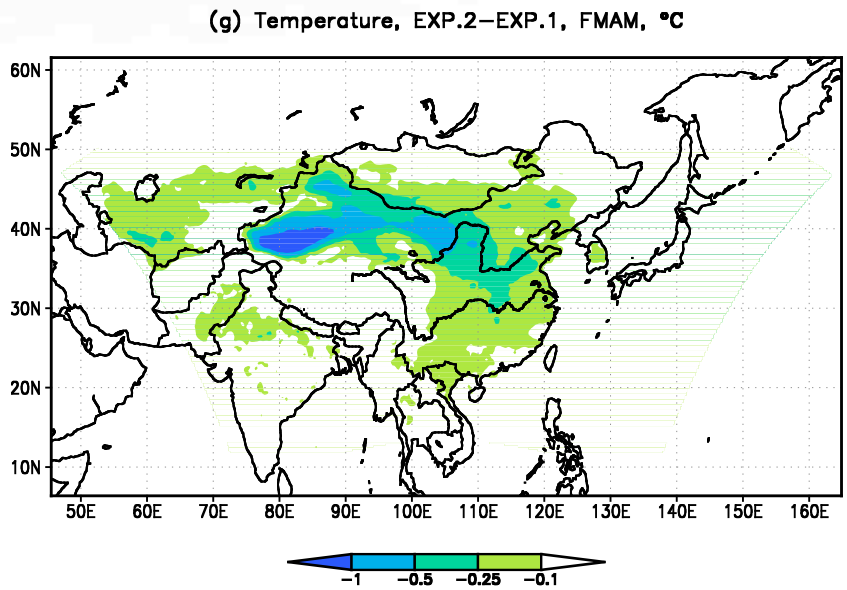


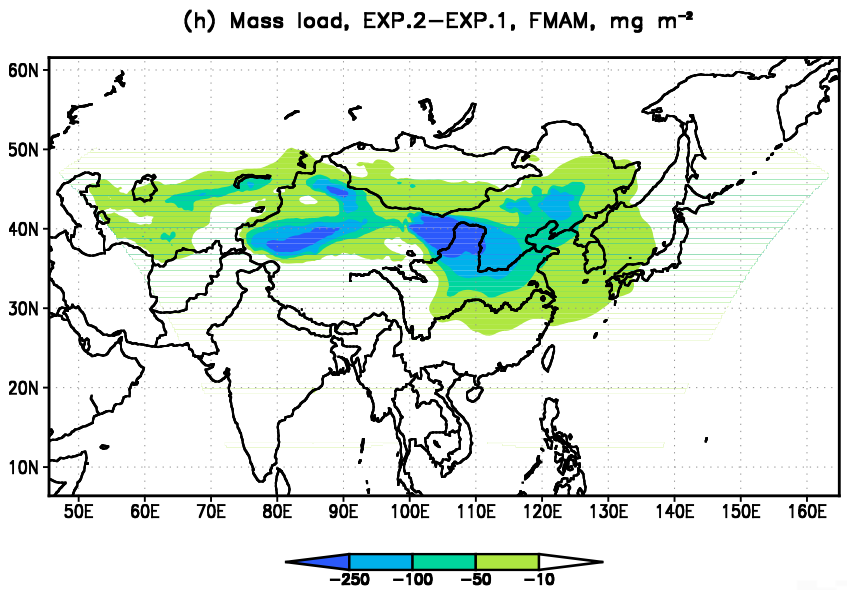
Effects on downward LW and net LW



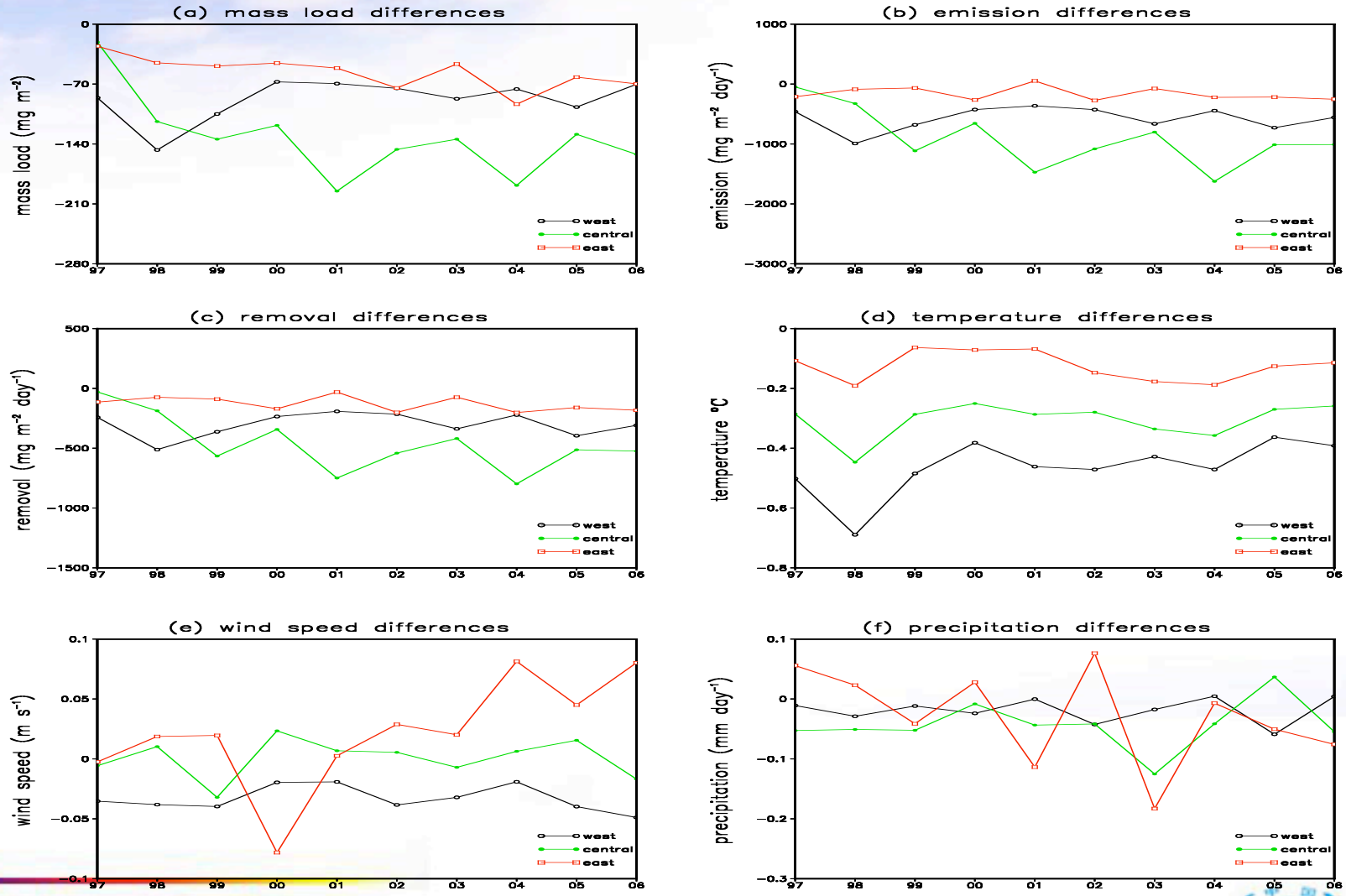


Effects on temperature and mass load





Feedbacks on climate over the subregions



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Results:

Negative TOA radiative forcing and surface forcing are found from the dust aerosol.

Atmospheric heating rates are increased and long-wave surface cooling rate are decreased.

Downward and long-wave radiation at the surface are decreased.

Decrease of temperatures and dust mass load are most pronounced over source areas.

The dust forcing decreases the emission remarkably.

Dust climate feedback weakens the dust process itself.

Limitation of the present work:

Contribution of other aerosols not included, e.g. sulfate, BC, et al.;

The indirect effects are not described;

The long-wave emissivity of dust does not been taken into account;

Future studies:

Further simulations with:

- multiple aerosols
- short and long wave radiative forcing
- indirect effects of dust

to study the role of natural and artificial aerosols in the formation of present climate over China and East Asia

To combine the aerosol with climate change:

- future changes of dust storms under the global warming
- role of aerosols in the changed climate
- air quality and climate change
- ……


THANK YOU !