



耶鲁大学-南京信息工程大学大气环境心

Yale-NUIST Center on Atmospheric Environment

# A discussion on modeling studies on CO<sub>2</sub> in urban environments

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# Outline

- Background
- Review of modeling studies on CO<sub>2</sub>
  - Global scale
  - Regional scale
  - Urban scale
- My work plan

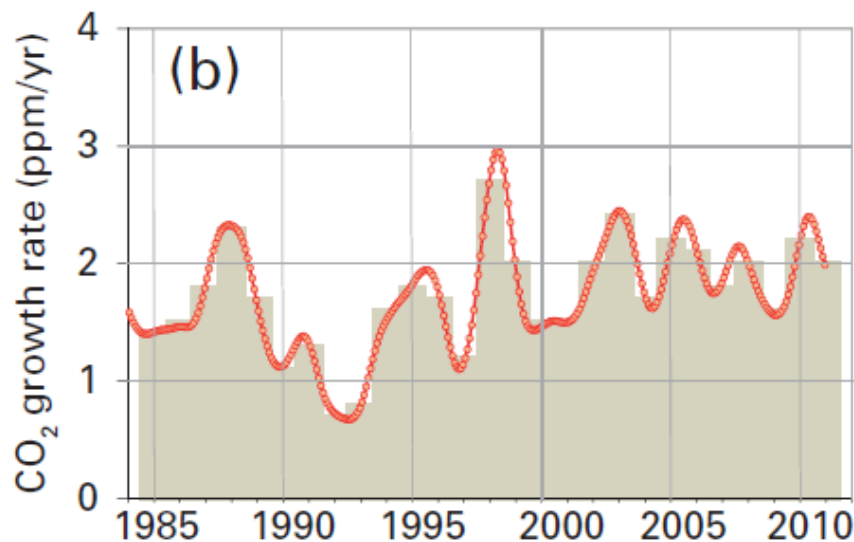
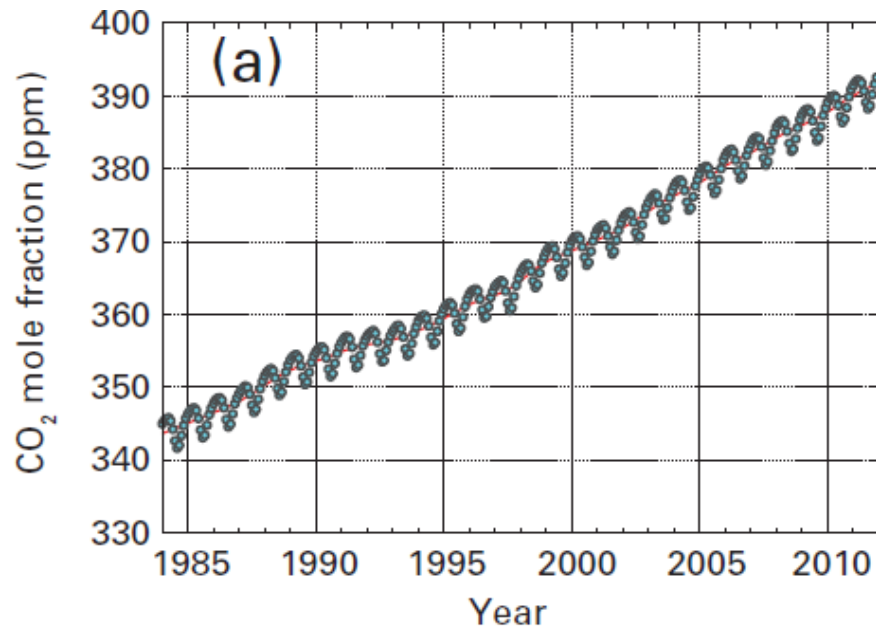


# Background

- Carbon dioxide ( $\text{CO}_2$ ), the most important greenhouse gas, is critical to climate change.
- Globally,  $\text{CO}_2$  increased from 345 ppm in 1985 to 390 in 2011, and is expected to continue to increase (WMO GHG bulletin 2011).
- In China, with the rapid urbanization and economic growth, anthropogenic emissions of  $\text{CO}_2$  in China increased by 2 to 4 times over the past several decades.
- It is important to investigate impact of human activities on the changes in  $\text{CO}_2$  in urban environment.



# The changes in global CO<sub>2</sub> during 1984-2011



(Source: 2011 WMO GHG bulletin)

# Sources and sinks of CO<sub>2</sub>

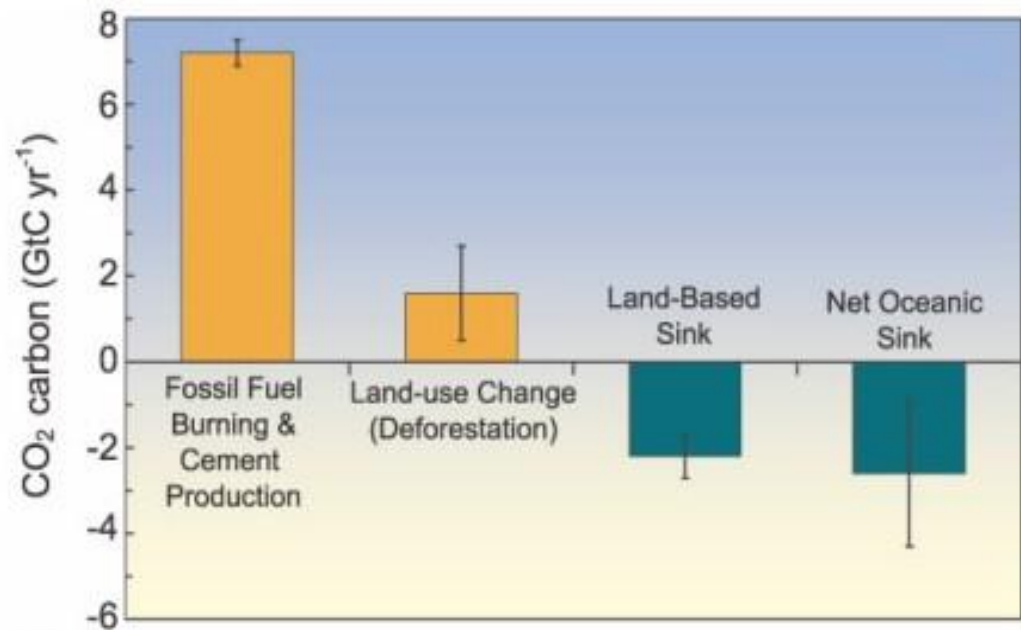
## Carbon dioxide sources

- Human-caused sources
  - Fossil Fuel Burning
  - Cement Production
- Natural sources
  - Land-use Change

## Carbon dioxide sinks

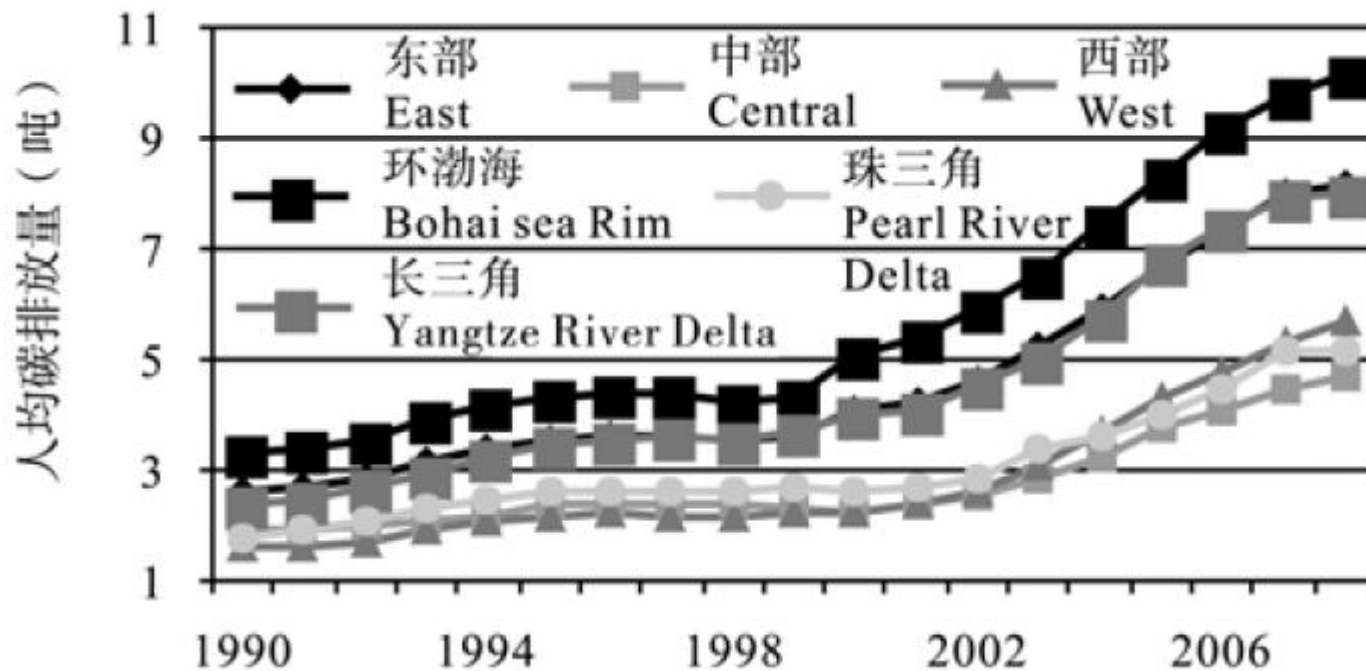
- Land-Based Sink
- Oceanic Sink

Carbon Dioxide



(Source:IPCC2007)

# Changes of CO<sub>2</sub> emissions in China during 1990-2008



(Source: National Bureau of Comprehensive Statistics Division, 2010)

# Modeling Studies on CO<sub>2</sub>

## ➤ Global models

### -TM3

TM3 is a global atmospheric tracer transport model with a spatial resolution of approximately  $4^\circ \times 5^\circ$ , 19 vertical levels. The model is driven by meteorological fields which from the NCEP reanalysis database.(Kalnay et al., 1996).

### - Carbon Tracker

Carbon Tracker is a global assimilation system developed by NOAA ESRL. (Wouter Peters et al.,2007)

➤ These global models provide lateral boundary and initial conditions to regional models



## ➤ **Regional models**

### - WRF-GHG or WRF-VPRM

The WRF Greenhouse Gas model (WRF-GHG) is an augmentation of the coupled Weather Research and Forecasting model (WRF) to the Vegetation Photosynthesis and Respiration model (VPRM). (Veronika Beck1 et al.,)

## ➤ WRF-GHG online calculated fluxes

-Biospheric CO<sub>2</sub>-the VPRM model is a diagnostic model that calculates hourly Net Ecosystem Exchange (NEE).

-Termite CO<sub>2</sub> flux: use the database for termite emissions of Sanderson(1996).

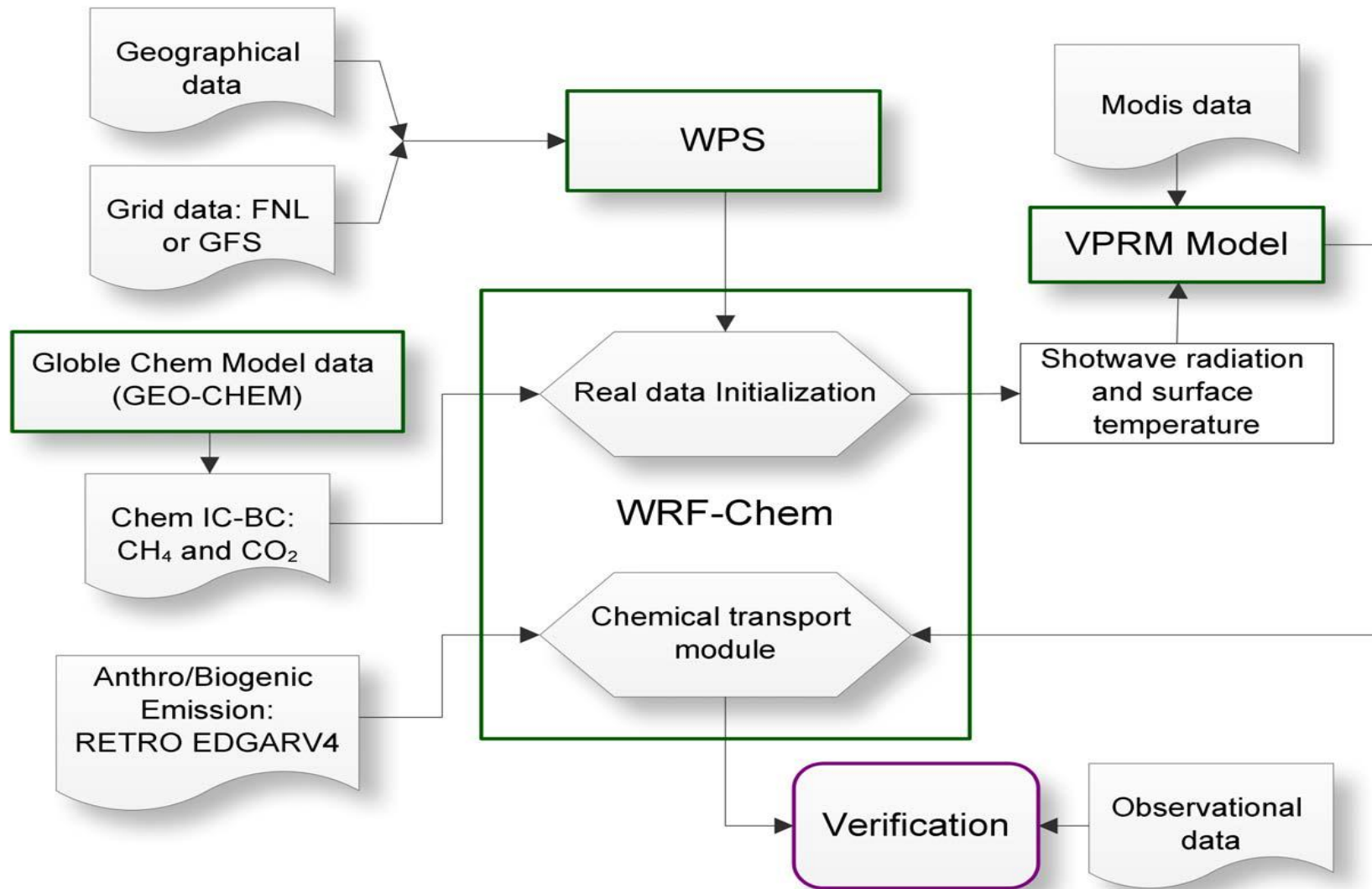
## ➤ WRF-GHG external flux data sets

-Biomass burning emissions for CO<sub>2</sub> :calculated as daily emissions based on satellite fire spots by a WRF-Chem preprocessor (Pre\_chem\_sources) developed by Karla Longo and Saulo Freitas.

-Authropogenic emissions for CO<sub>2</sub>: data from EDGAR and IER

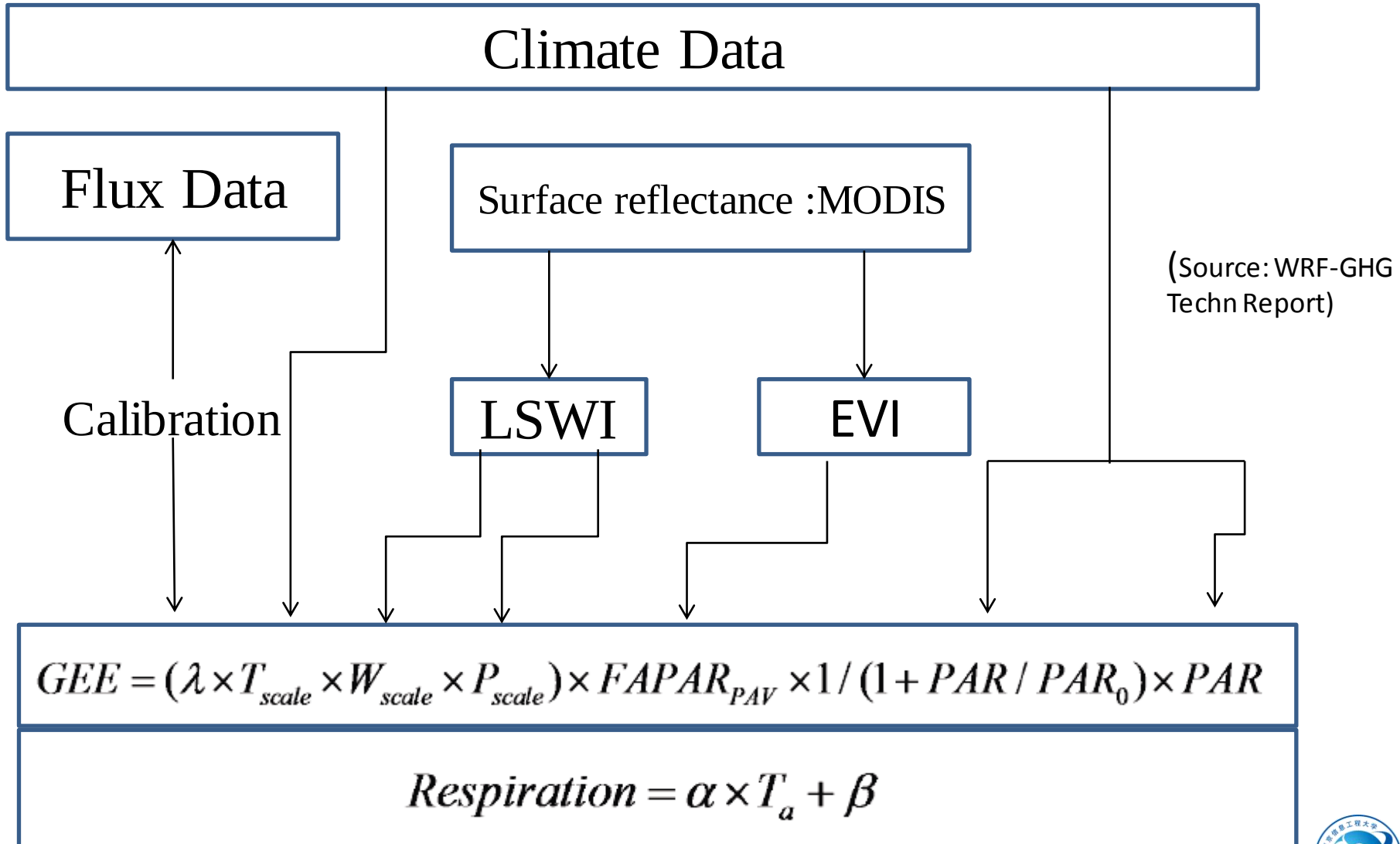


# WRF-GHG



(Source: Diaoyiwei)

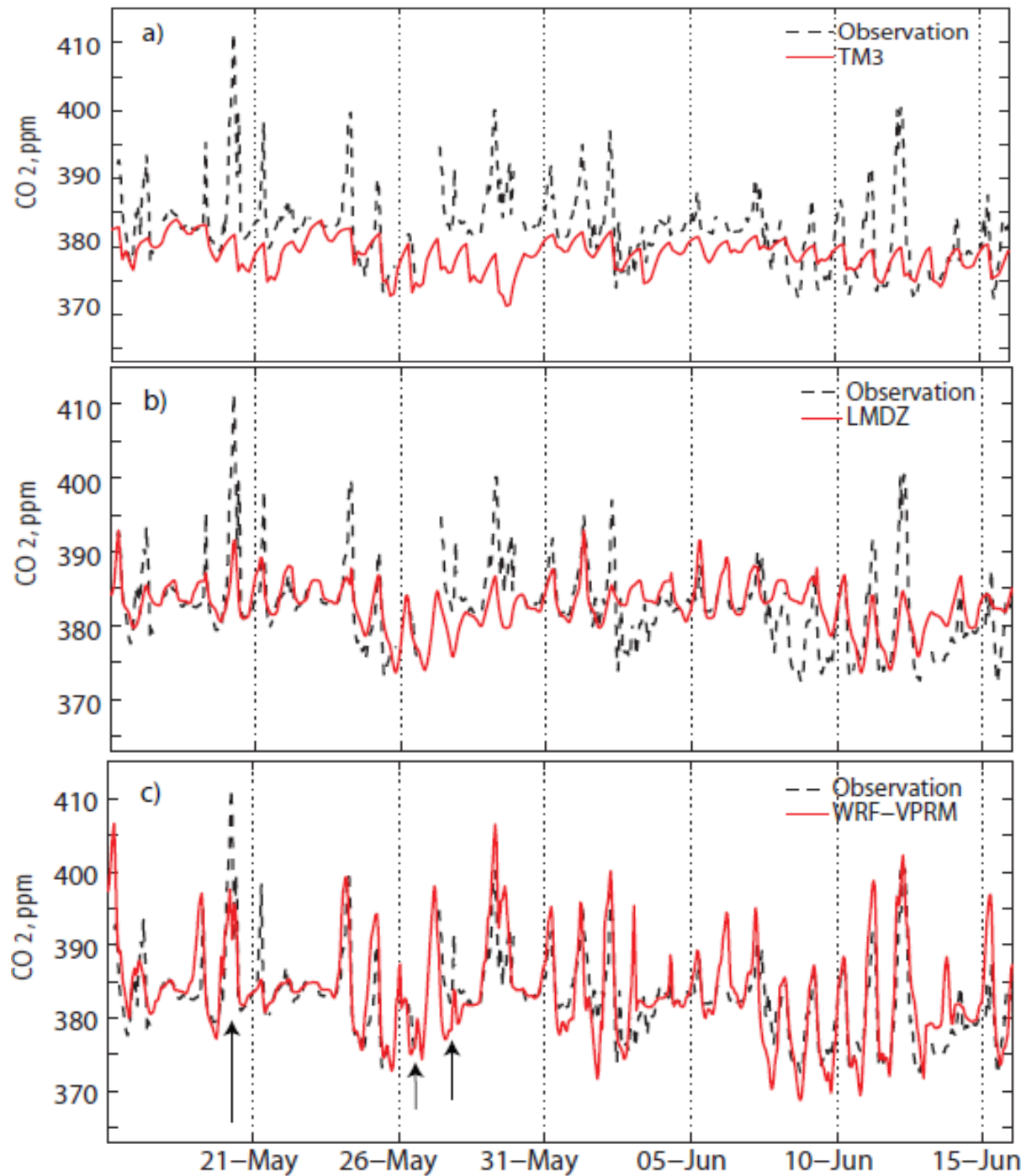
# VPRM Model



# Applications of WRF/GHG to CO<sub>2</sub> modeling

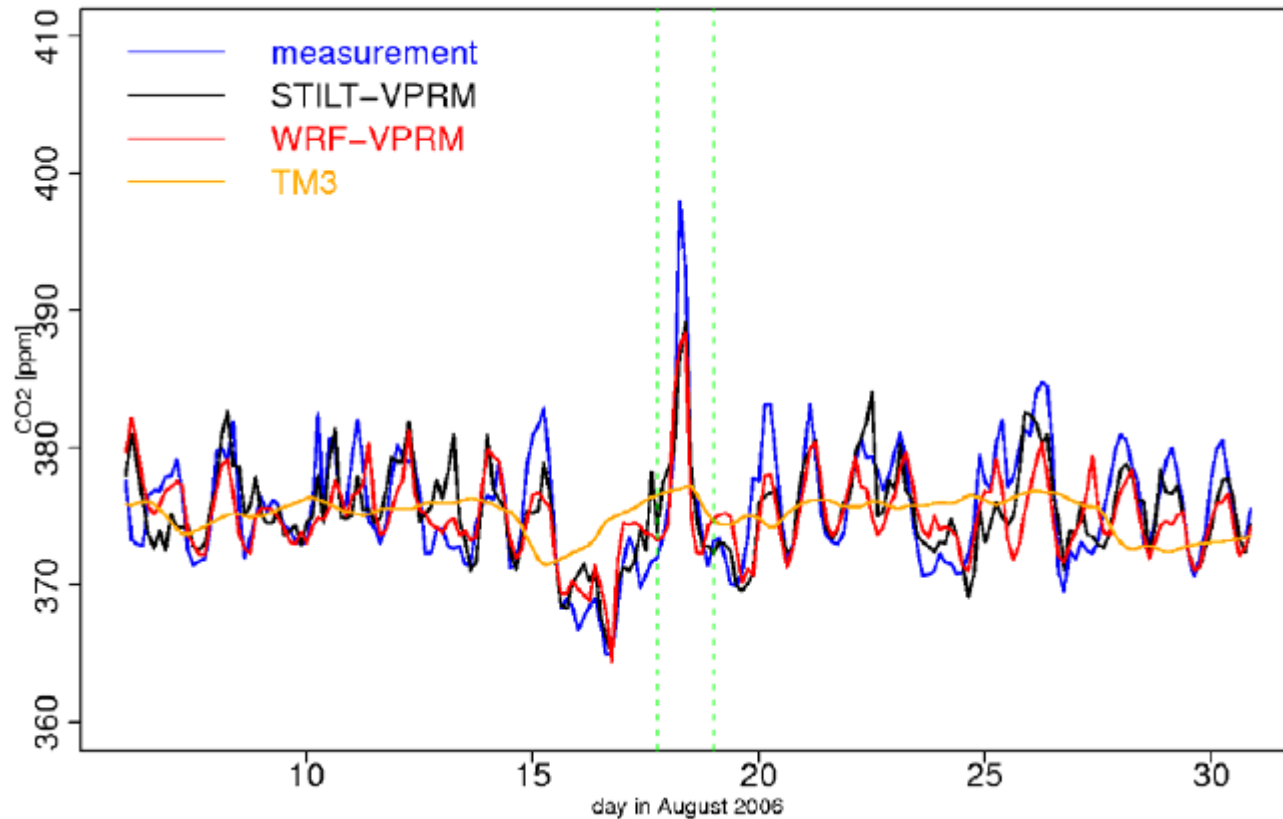
- R.Ahmadov et al.(2009)used WRF-VPRM to compare with two global models . They found that WRF-VPRM can capture the measured CO<sub>2</sub> signal much better than the global models due to the coarse resolution.
- D.Pillai et al.(2011)used WRF-VPRM to investigate the ability of high-resolution modeling tools to simulate meteorological and CO<sub>2</sub> fields. The results suggest that the high-resolution models can capture diurnal, seasonal and synoptic variability of observed mixing ratios much better than coarse global models.

Biscarosse station, 16.05–15.06.2005



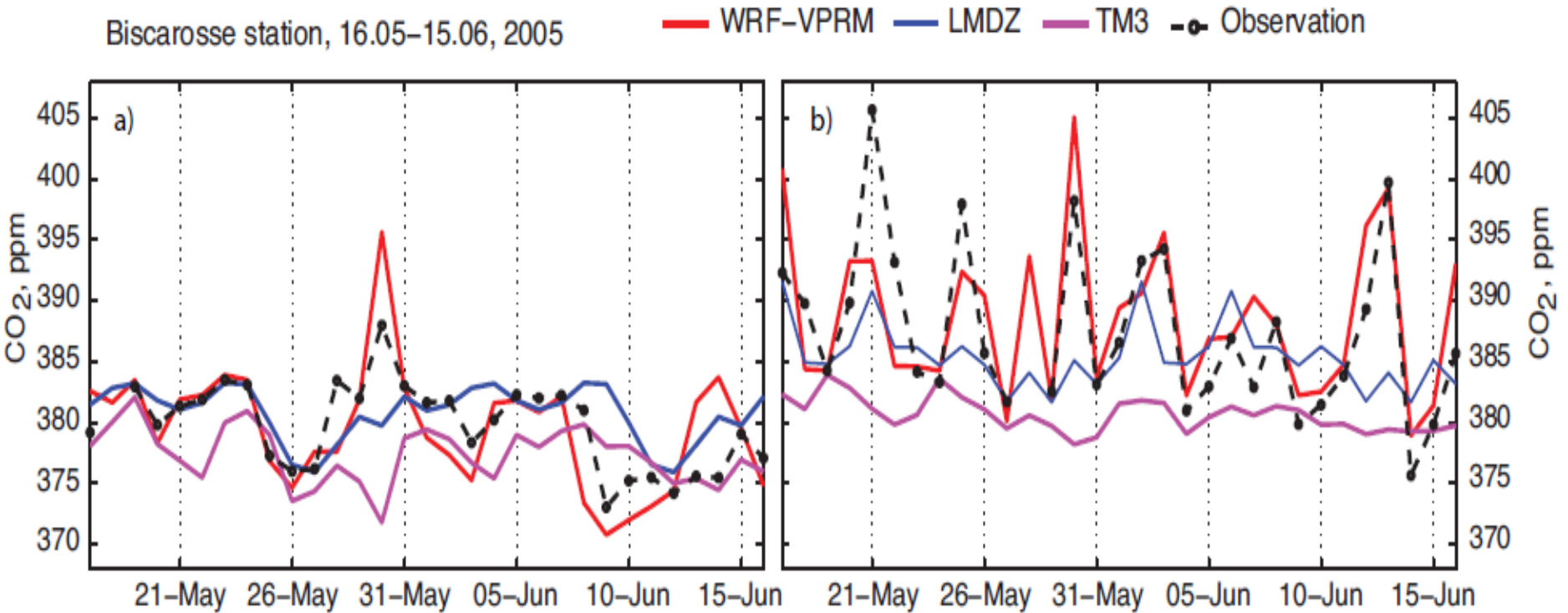
CO<sub>2</sub> concentration  
time series  
comparison  
(Source: R. Ahmadov  
et al. 2009)

# Comparison of measured and modeled CO<sub>2</sub> concentrations



(Source: D.Pillai et al.,2011)

# Comparison of measured CO<sub>2</sub> concentration against the models for daytime and nighttime



(Source: R.Ahmadov et al.2009)

# Modeling studies of CO<sub>2</sub> on urban scale

- Most current existing research works of CO<sub>2</sub> are related to observational studies. Regional modeling studies of CO<sub>2</sub> are very limited.
- Our study will use WRF-GHG to simulate CO<sub>2</sub> on urban scale.
- The possible difficulties and challenges for modeling CO<sub>2</sub> at fine resolution
  - Fine resolution anthropogenic emission inventory.
  - Well-designed CO<sub>2</sub> monitoring network to provide observational data for model performance evaluation.

# My work plan

- Our study will focus on urban scale (Nanjing).
- To simulate diurnal and spatial patterns of CO<sub>2</sub> on regional scale.
- To estimate the urban scale flux and evaluated quantitatively of contributions to CO<sub>2</sub> concentration variation from anthropogenic emissions and natural source and sink.
- Try to predict the future urbanization development impact on greenhouse gases variation ,and try to provide a scientific basis for GHGs emission reduction.

*Thank you*