Coupling and testing of WRF-GHG

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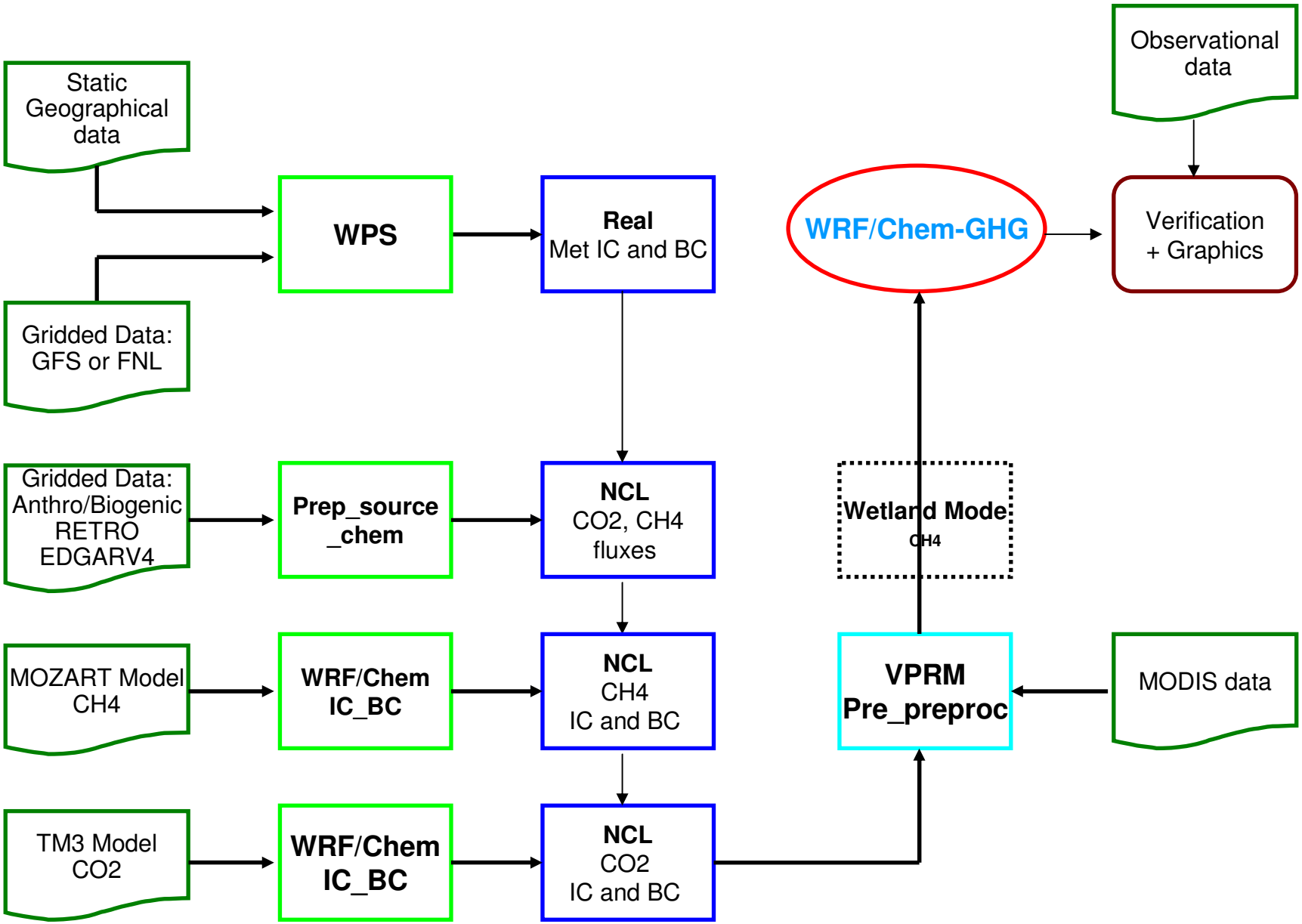
10-27-2011

Outline

- WRF-GHG
- Developmental testing
- Summary
- On-going work and Next steps



Flow Chart of the coupling system of WRF-GHG

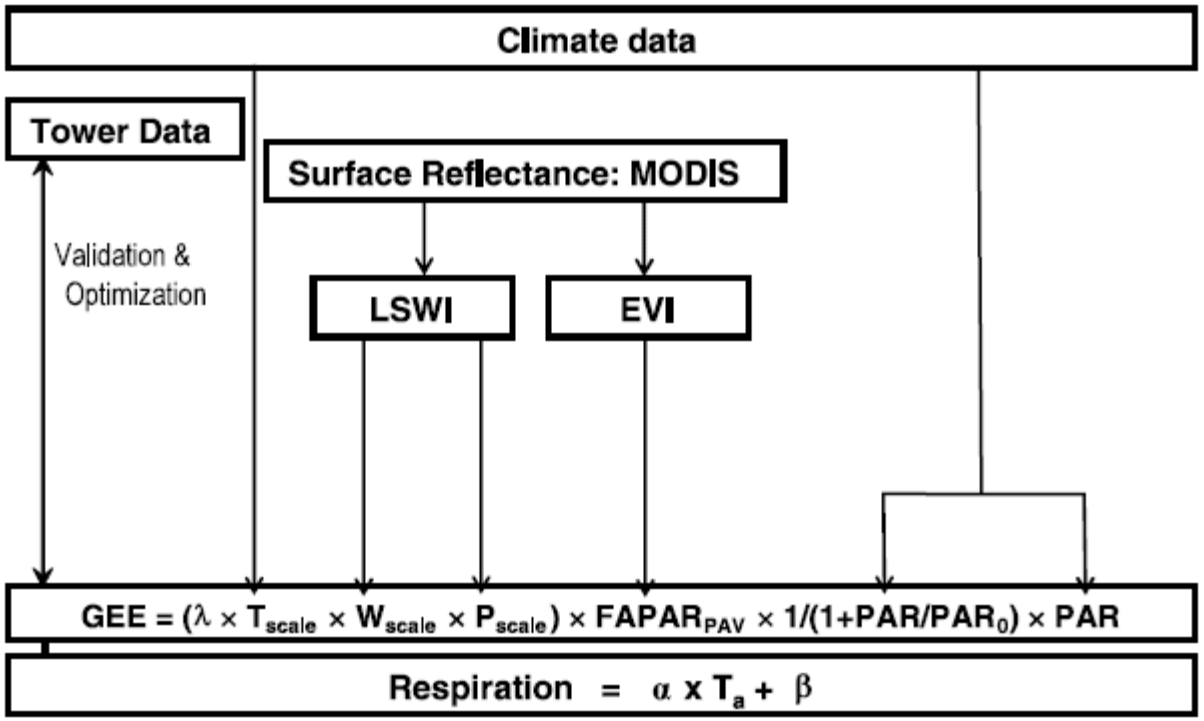
VPRM

- Gross Ecosystem Exchange (GEE)

$$GEE = \lambda \times T_{scale} \times P_{scale} \times W_{scale} \times EVI \times \frac{1}{1 + \frac{PAR}{PAR_0}} \times PAR$$

where λ is a factor for the maximum quantum yield and PAR_0 is the half-saturation value of the photosynthetically active radiation (PAR). Tscale, Pscale, and Wscale are scalars for temperature, leaf phenology, and canopy water content, respectively. The VPRM model uses 8 different vegetation classes.

VPRM (cont.)

- 

Schematic diagram of the Vegetation Photosysnthesis Respiration Model (VPRM) (source: Mahadevan et al. 2008)

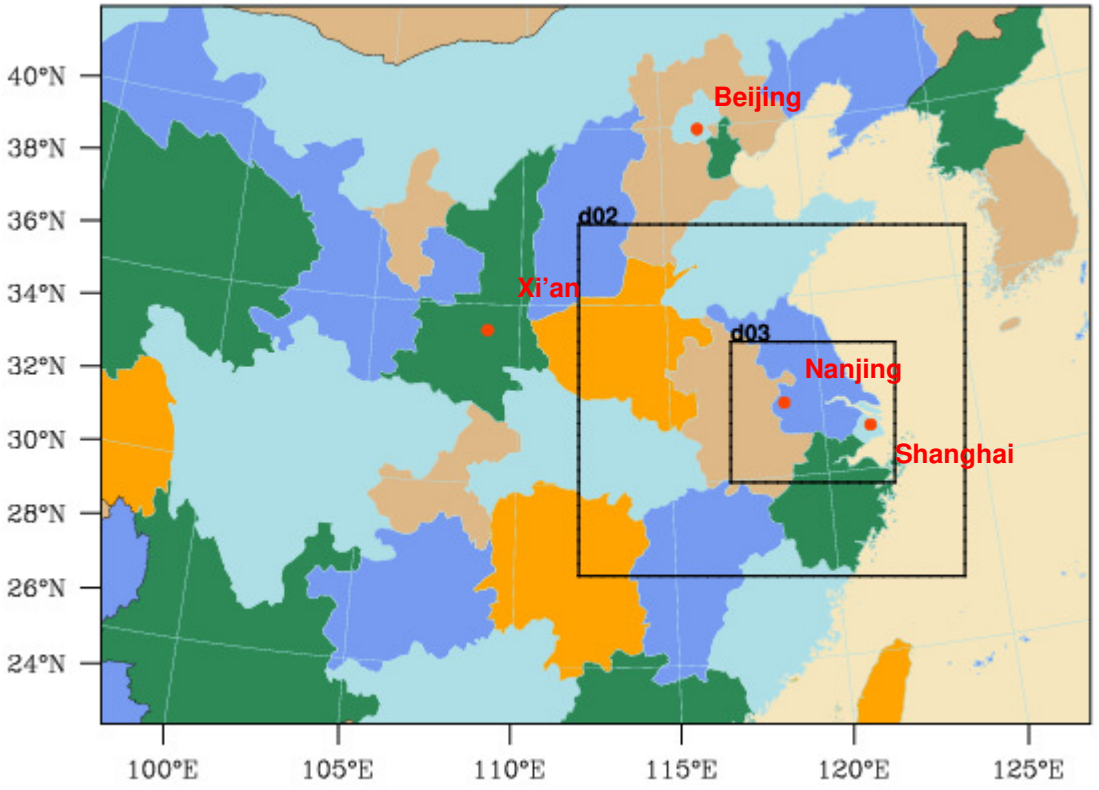
Domain set-up

D1: 80 x 60, 36 km

D2: 100 x 91, 12 km

D3: 121 x 100, 4 km

Vertical levels: 40



CO_2 related tracer variables defined in the registry.ghg file

Variables (CO_2)	**Tracer**
CO2_1	total atmospheric CO_2 concentration
CO2_2	changes in CO_2 concentration from biogenic activity
CO2_3	changes in CO_2 concentration from anthropogenic emissions
CO2_4	changes in CO_2 concentration from biomass burning
CO2_5	changes in CO_2 concentration from termites
CO2_6	changes in CO_2 concentration from ocean fluxes
CO2_B	Atmospheric CO_2 background concentration

CH_4 related tracer variables defined in the registry.ghg file

Variables (CH_4)	**Tracer**
CH4_1	total atmospheric CH_4 concentration
CH4_2	changes in CH_4 concentration from wetland emissions
CH4_3	changes in CH_4 concentration from anthropogenic emissions
CH4_4	changes in CH_4 concentration from biomass burning
CH4_5	changes in CH_4 concentration from termite emissions
CH4_6	changes in CH_4 concentration from soil uptake
CH4_7	changes in CH_4 concentration from vegetation
CH4_B	atmospheric CH_4 background concentration

CO_2 flux variables used in the WRF-GHG

Variables	**Flux component**	**Time Dimension**
fl_bio1	ext. biospheric	hourly [30]
fl_oce	ext. ocean	hourly [30]
fl_ant1	ext. anthropogenic	daily [1]
fl_antco2	ext. anthropogenic	hourly [30]
fl_bbco2	ext. biomass burning	daily [1]
fb_co2	3d. int. biomass burning	WRF timestep
GEE	int. Gross-Ecosystem-Exchange	WRF timestep
RESP	Int. biospheric respiration	WRF timestep
co2_term	int. termite emission	WRF timestep

CH_4 flux variables used in the WRF-GHG

Variables	**Flux component**	**Time Dimension**
fl_wet	ext. wetland	hourly [30]
fl_ant4	ext. anthropogenic	daily [1]
fl_antch4	ext. anthropogenic	hourly [30]
fl_bbch4	int. biomass burning	daily [1]
fl_ch4	3d int. biomass burning	WRF timestep
fl_term	ext. termite emission	daily [1]
fl_soilu	ext. soil uptake	hourly [30]
fl_veg	ext. vegetation	hourly [30]
ch4_emiss	int. wetland	WRF timestep
Ch4_term	int. termite emission	WRF timestep
Ch4_soil	int. soil uptake	WRF timestep
Ch4_veg	int. vegetation	WRF timestep

Global model data used for ICs and BCs

Variable	**Model**	**Horizontal res.**	**Vertical level**	**Time interval**
Met	**GFS**	1^o x 1^o	27	3-h
CO_2	**TM3**	4^o x 5^o	19	6-h
CH_4	**MOZART**	2.8125^o x 2.8125^o	65	6-h

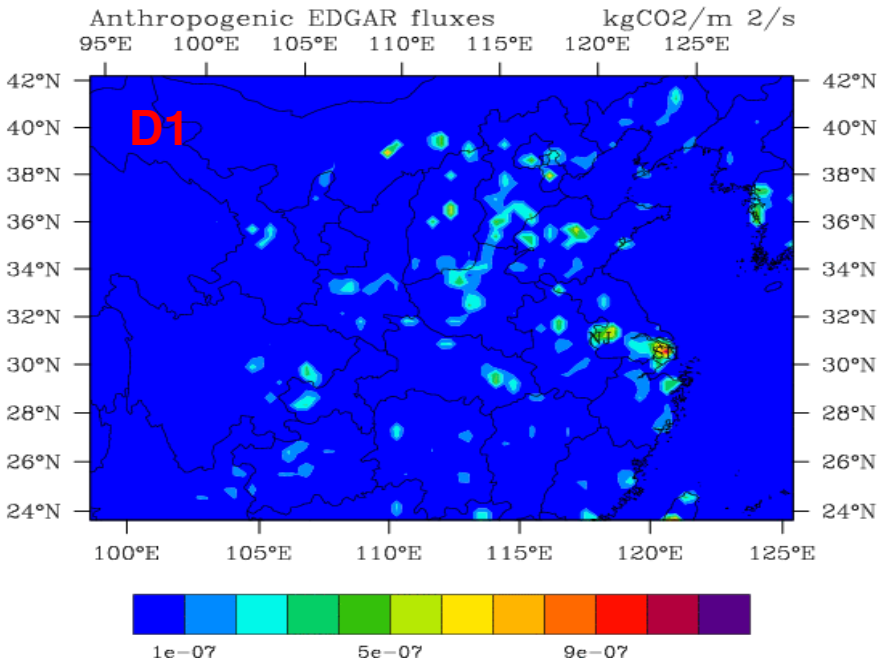
GFS: Global Forecasting System

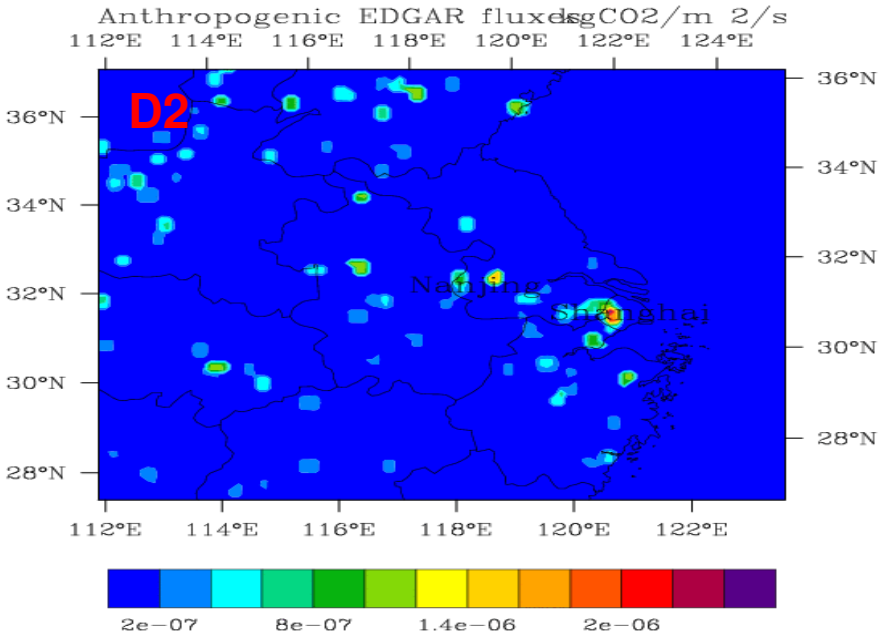
TM3: Global Chemistry – Transport Model 5

MOZART: The Model of OZone And Related Tracer species

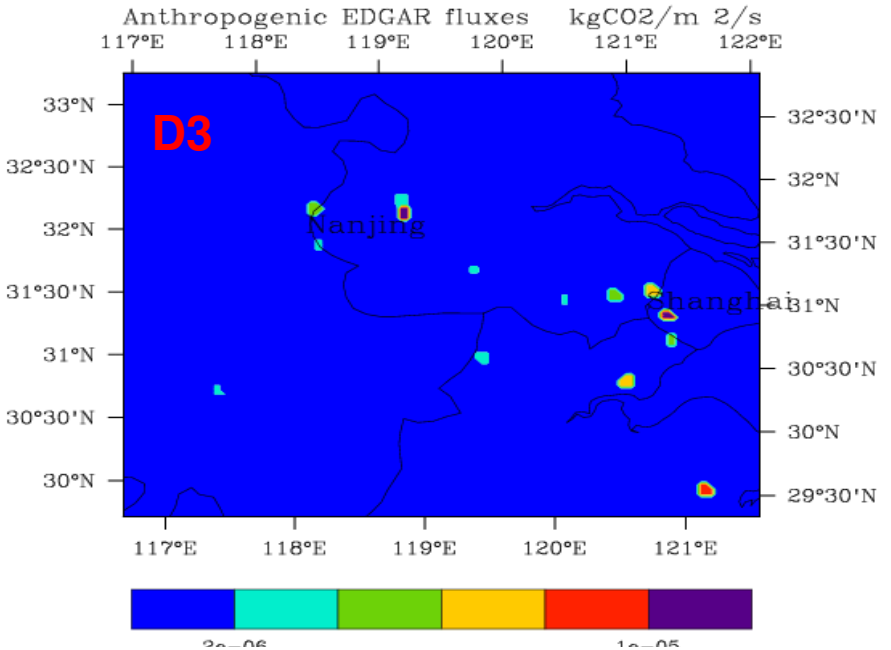
Processing anthropogenic emissions

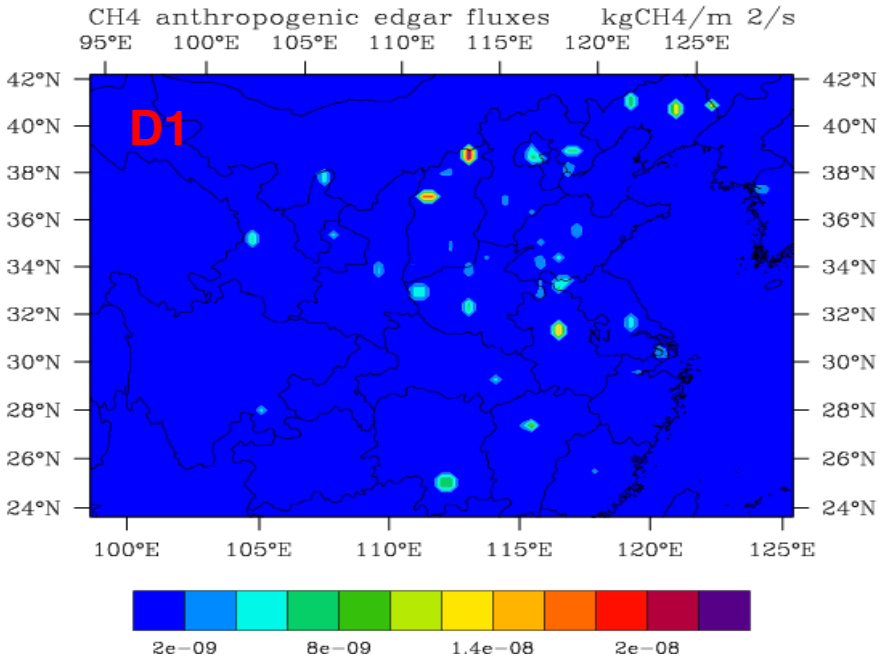
- Source code: pre_chem_sources
- Emission data: Emission Database for Global Atmospheric Research version 4 (EDGAR4) at http://www.mnp.nl/edgar
- Base year: 2005
- Resolution: $1^{o} \times 1^{o}$
- Species: CH_4, CO, CO_2, N_2O, NMVOC, NOx, SF_6, SO_2, SULF

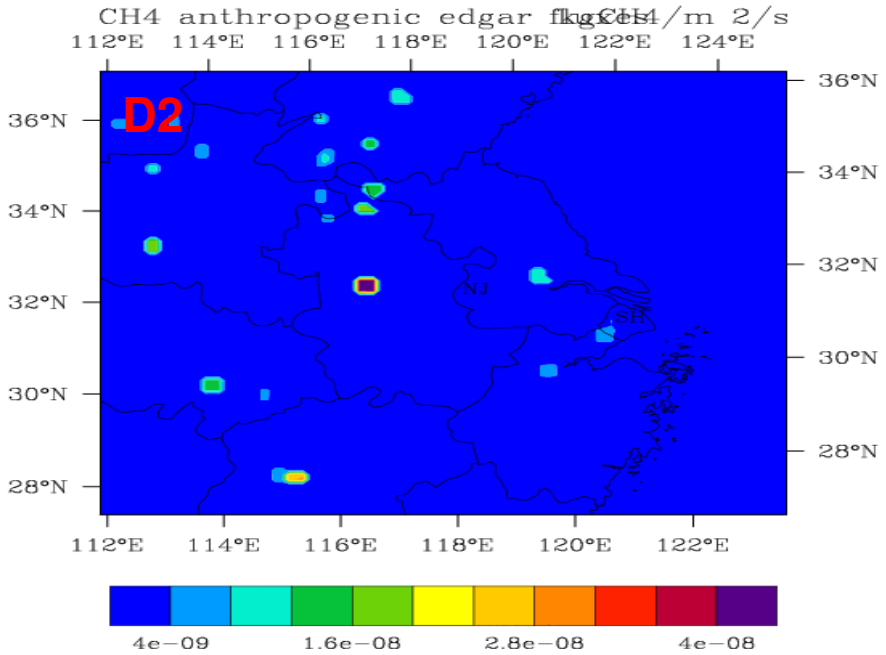




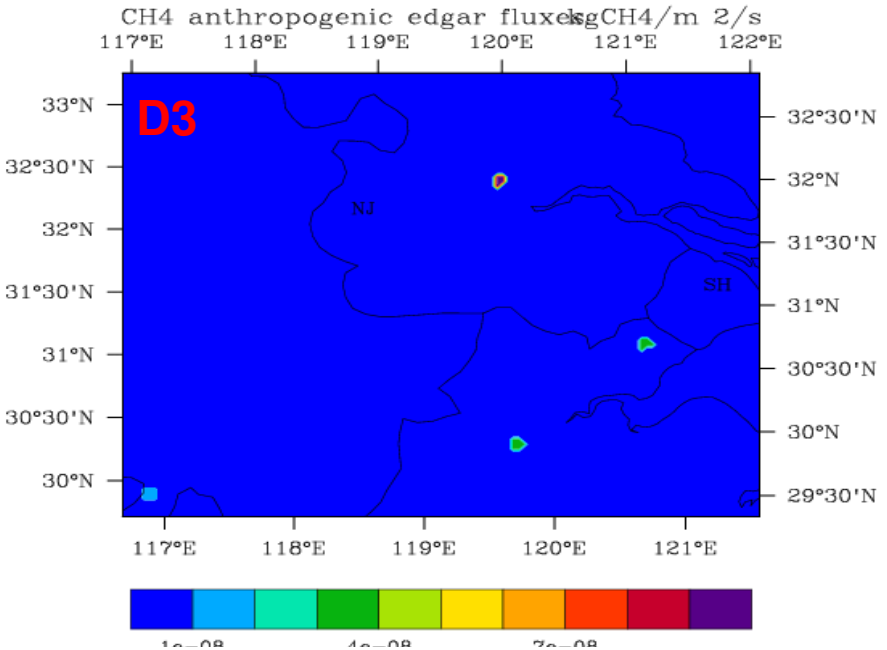
Anthropogenic Fluxes of CO_2





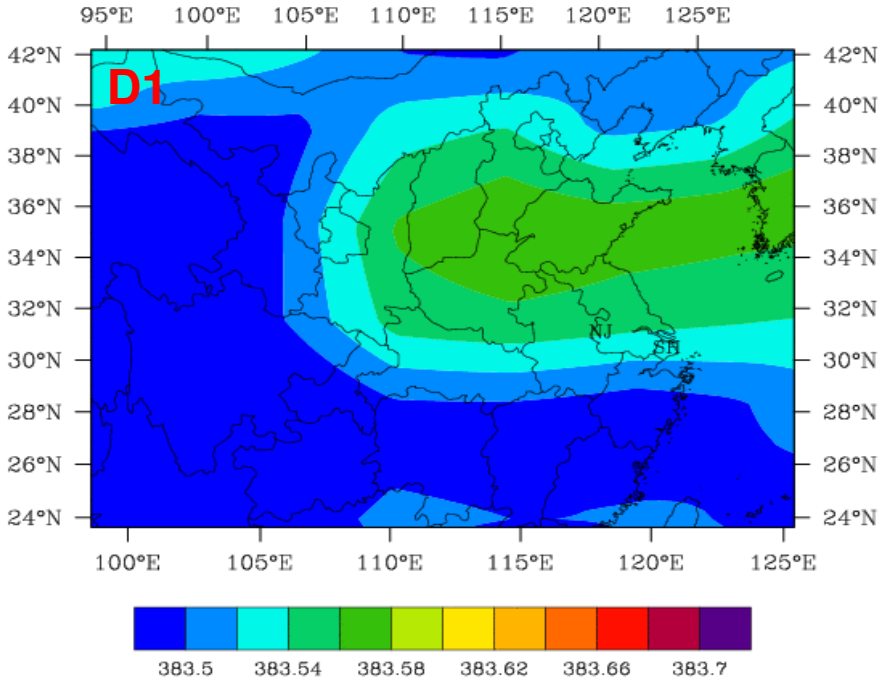


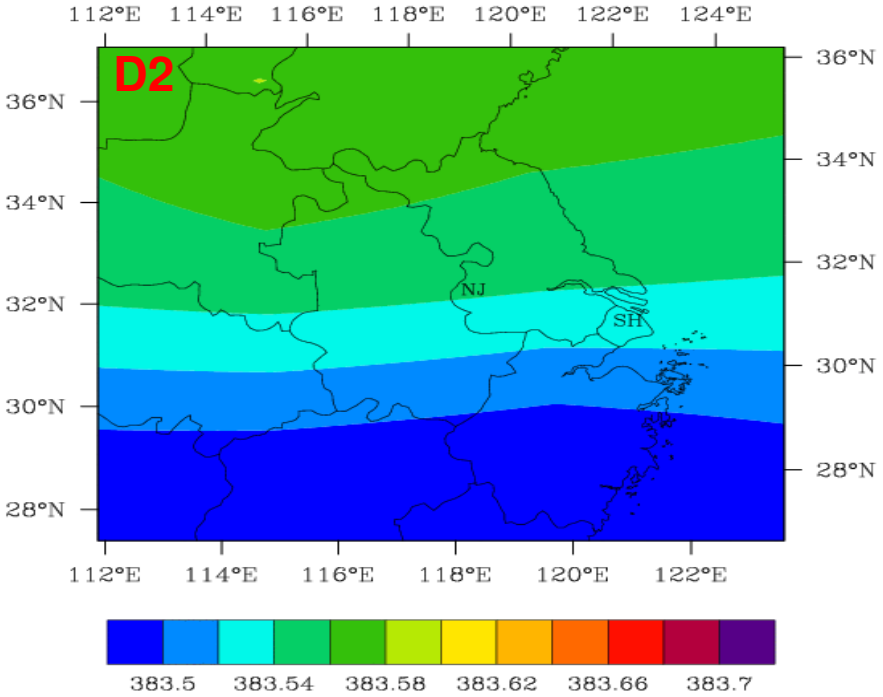
Anthropogenic Fluxes of CH_4



Processing ICs and BCs

- Source code: modify wrfchembc v2.2
- Horizontal and vertical interpolations
- Using wrfchembc for domain 1 and NCL for domains 2 and 3

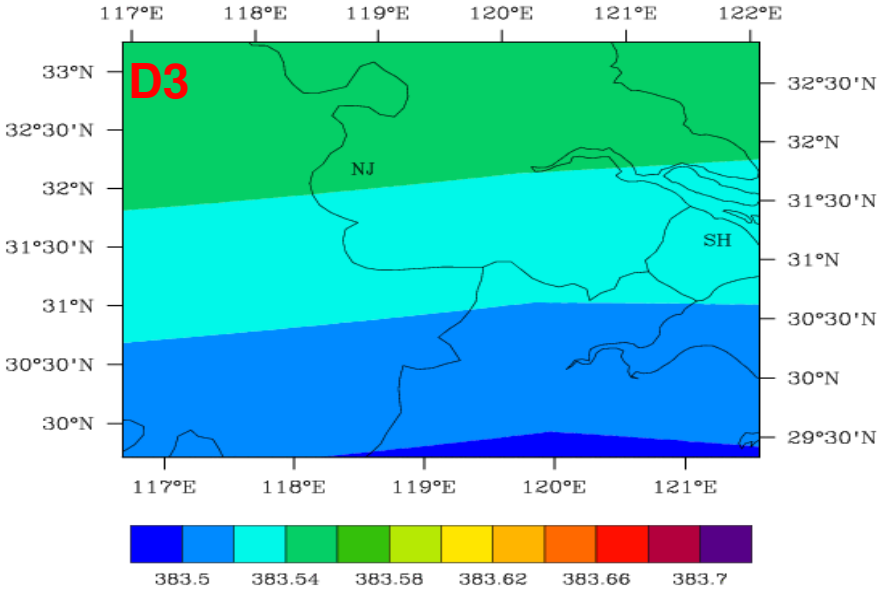


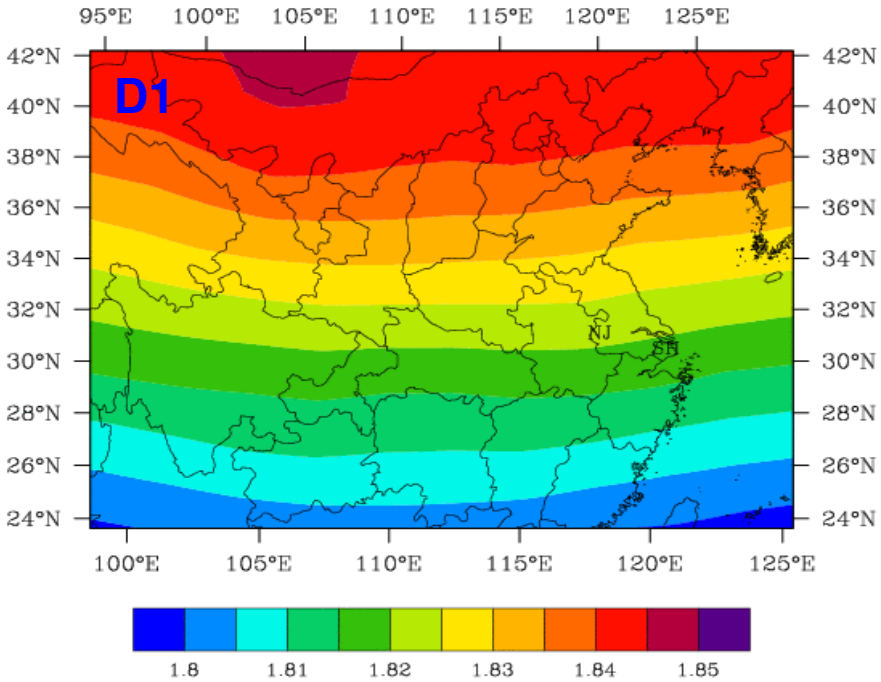


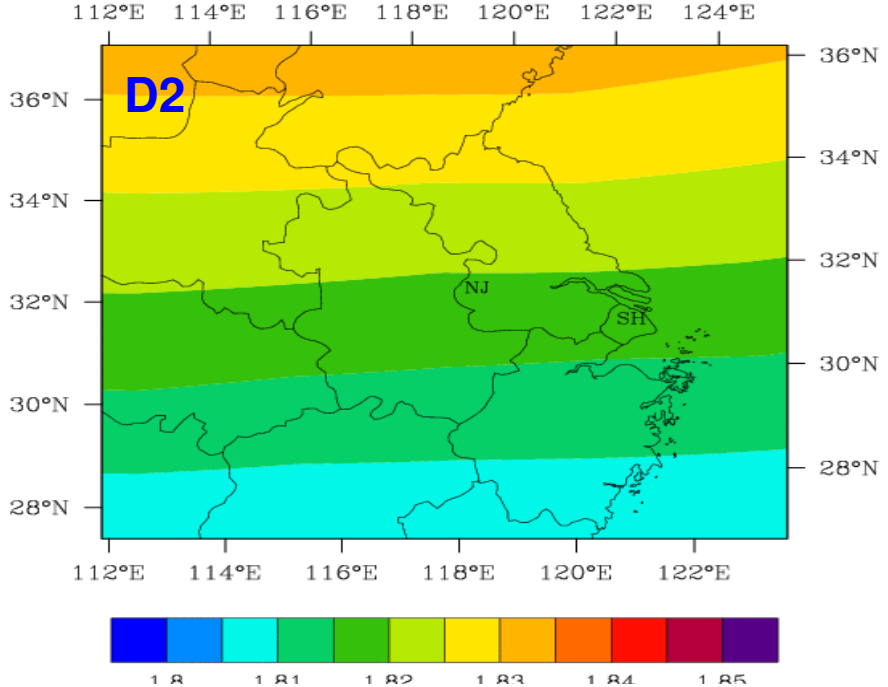
CO_2

Global model: TM3

Initialized at 12:00 UTC 08-03-2011



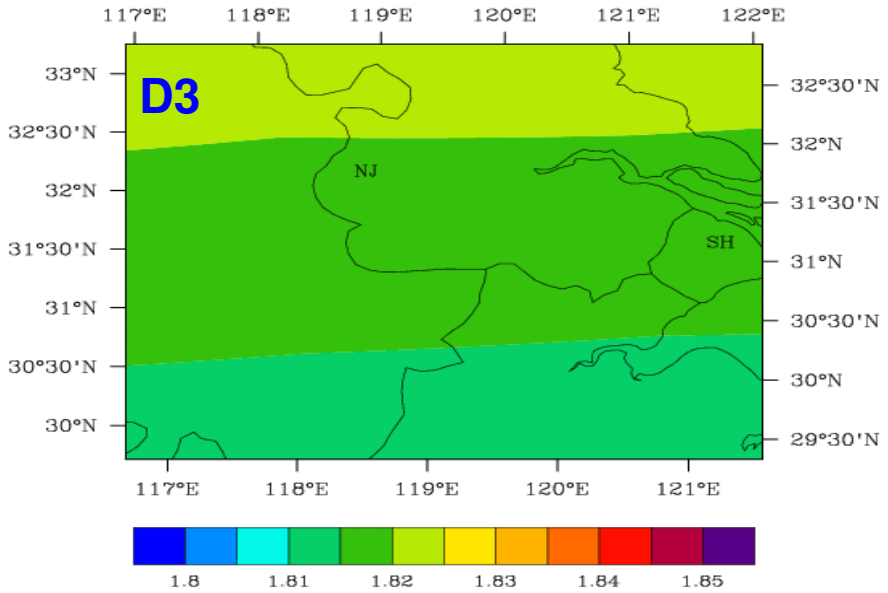




CH_4

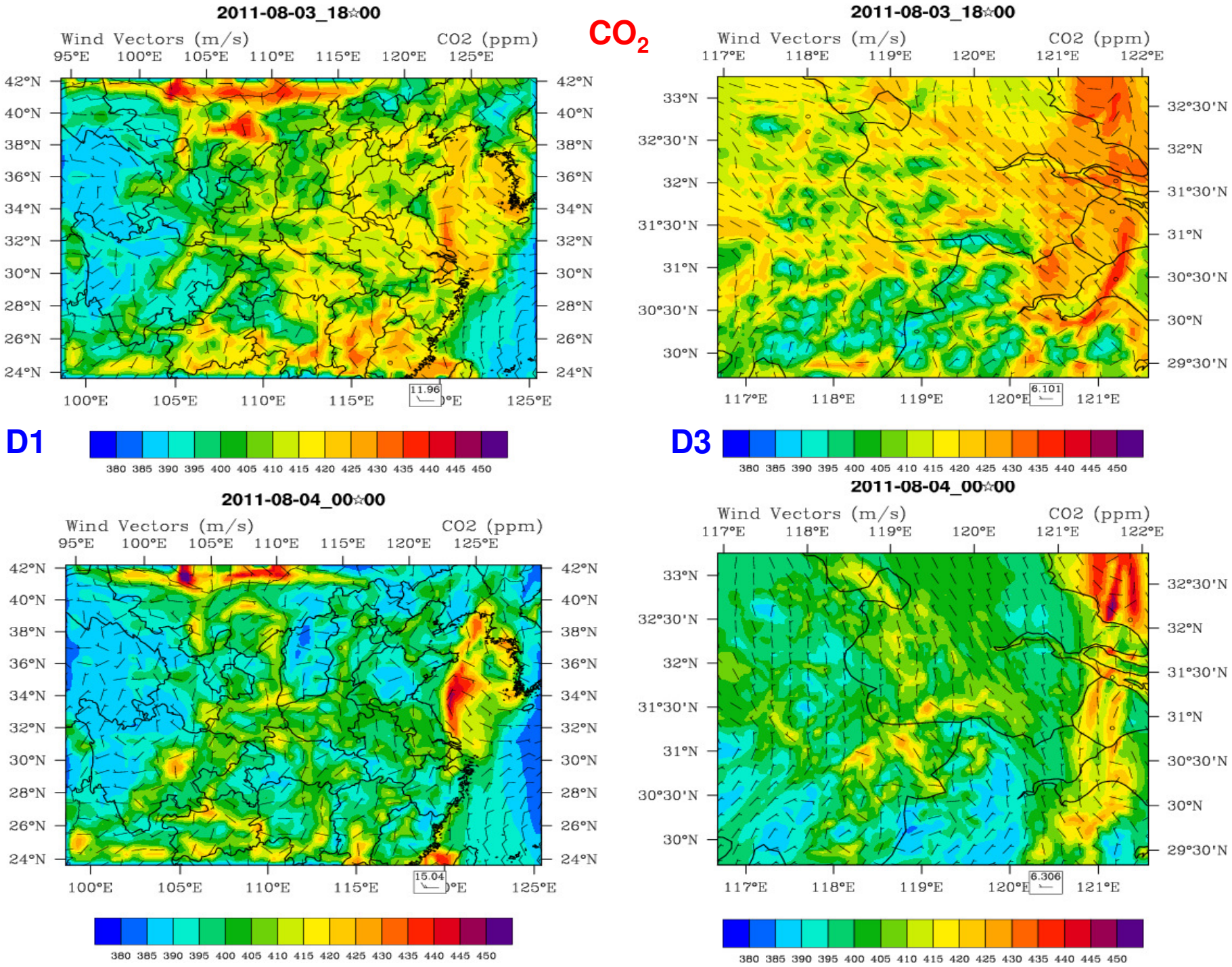
Global model: MOZART

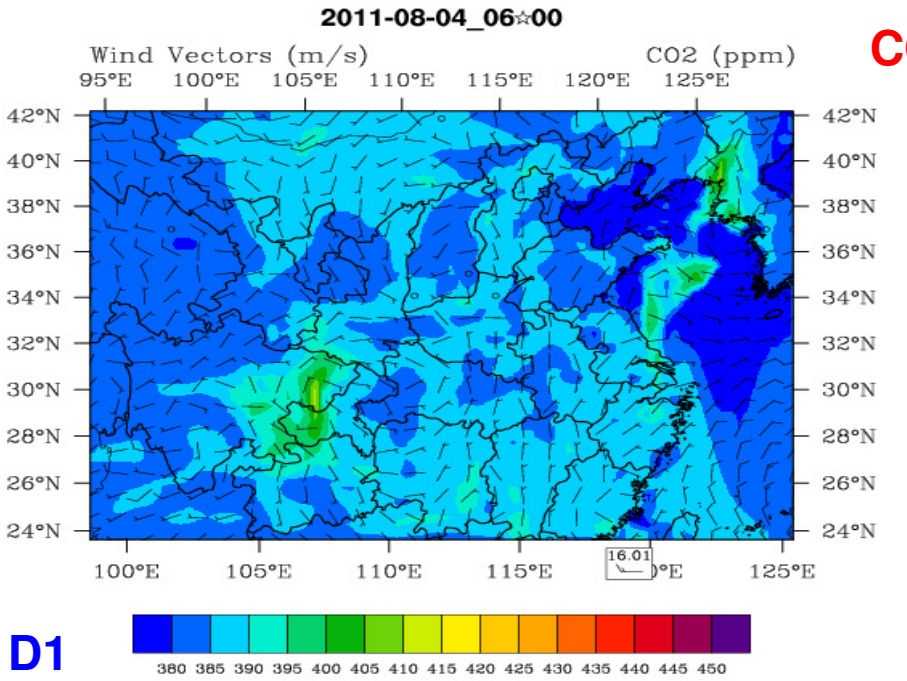
Initialized at 12:00 UTC 08-03-2011



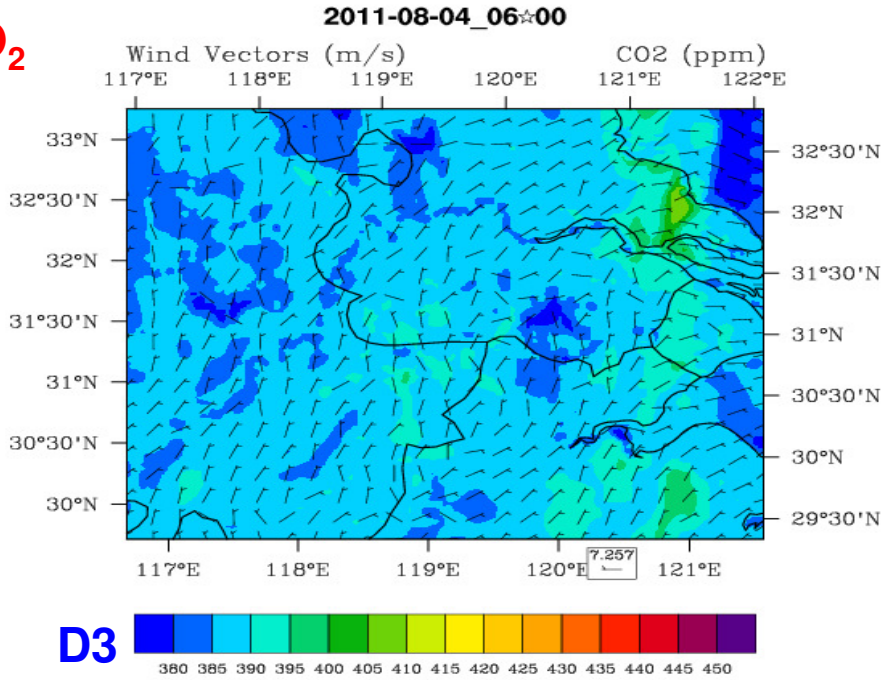
Physics options in WRF/ARW

Physical schemes	**D1**	**D2**	**D3**
Radiation	RRTMG scheme (longwave) CAM scheme (shortwave)	RRTMG scheme (longwave) CAM scheme (shortwave)	RRTMG scheme (longwave) CAM scheme (shortwave)
Microphyiscs	WSM 5-class scheme	WSM 5-class scheme	WSM 3-class scheme
Cumulus parameterization	Grell-Devenyi (GD) ensemble scheme	Improved Grell 3D scheme	Improved Grell 3D scheme
PBL parameterization	MYJ scheme	MYJ scheme	MYJ scheme
Surface layer	Monin-Obukhov scheme	Monin-Obukhov scheme	Monin-Obukhov scheme
Land surface model	NOAH-LSM	NOAH-LSM	NOAH-LSM


2011-08-03_18☆00
Wind Vectors (m/s)
CO2 (ppm)
95°E 100°E 105°E 110°E 115°E 120°E 125°E
42°N 40°N 38°N 36°N 34°N 32°N 30°N 28°N 26°N 24°N
100°E 105°E 110°E 115°E 125°E
11.96
CO2
2011-08-03_18☆00
Wind Vectors (m/s)
CO2 (ppm)
117°E 118°E 119°E 120°E 121°E 122°E
33°N 32°30'N 32°N 31°30'N 31°N 30°30'N 30°N
32°30'N 32°N 31°30'N 31°N 30°30'N 30°N 29°30'N
117°E 118°E 119°E 120°E 121°E
6.101
D1
380 385 390 395 400 405 410 415 420 425 430 435 440 445 450
D3
380 385 390 395 400 405 410 415 420 425 430 435 440 445 450
2011-08-04_00☆00
Wind Vectors (m/s)
CO2 (ppm)
95°E 100°E 105°E 110°E 115°E 120°E 125°E
42°N 40°N 38°N 36°N 34°N 32°N 30°N 28°N 26°N 24°N
100°E 105°E 110°E 115°E 125°E
15.04
380 385 390 395 400 405 410 415 420 425 430 435 440 445 450
2011-08-04_00☆00
Wind Vectors (m/s)
CO2 (ppm)
117°E 118°E 119°E 120°E 121°E 122°E
33°N 32°30'N 32°N 31°30'N 31°N 30°30'N 30°N
32°30'N 32°N 31°30'N 31°N 30°30'N 30°N 29°30'N
117°E 118°E 119°E 120°E 121°E
6.306
380 385 390 395 400 405 410 415 420 425 430 435 440 445 450

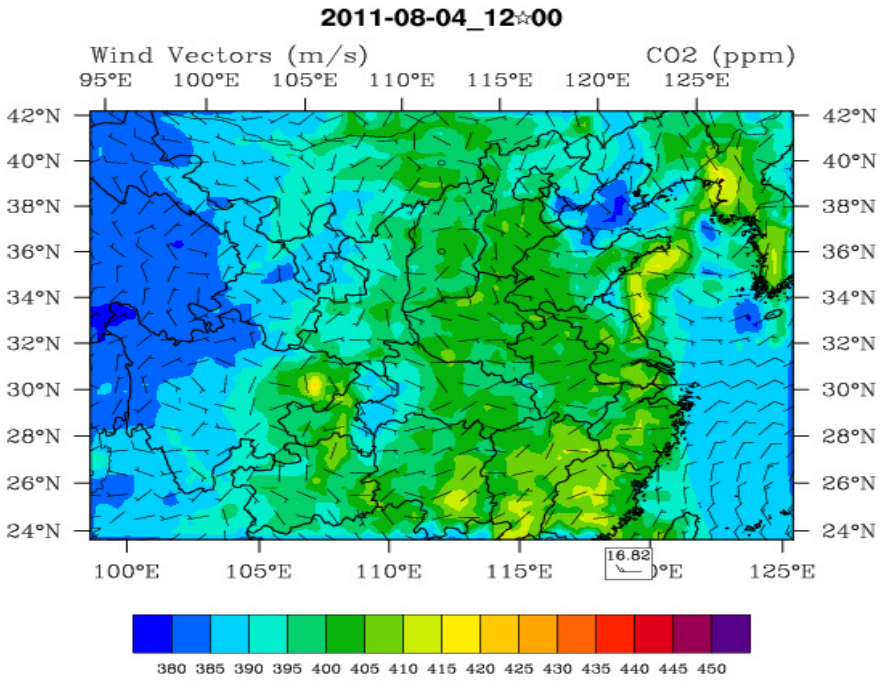

2011-08-04_06☆00
Wind Vectors (m/s)
CO2 (ppm)
95°E 100°E 105°E 110°E 115°E 120°E 125°E
42°N 40°N 38°N 36°N 34°N 32°N 30°N 28°N 26°N 24°N
100°E 105°E 110°E 115°E 120°E 125°E
16.01
380 385 390 395 400 405 410 415 420 425 430 435 440 445 450

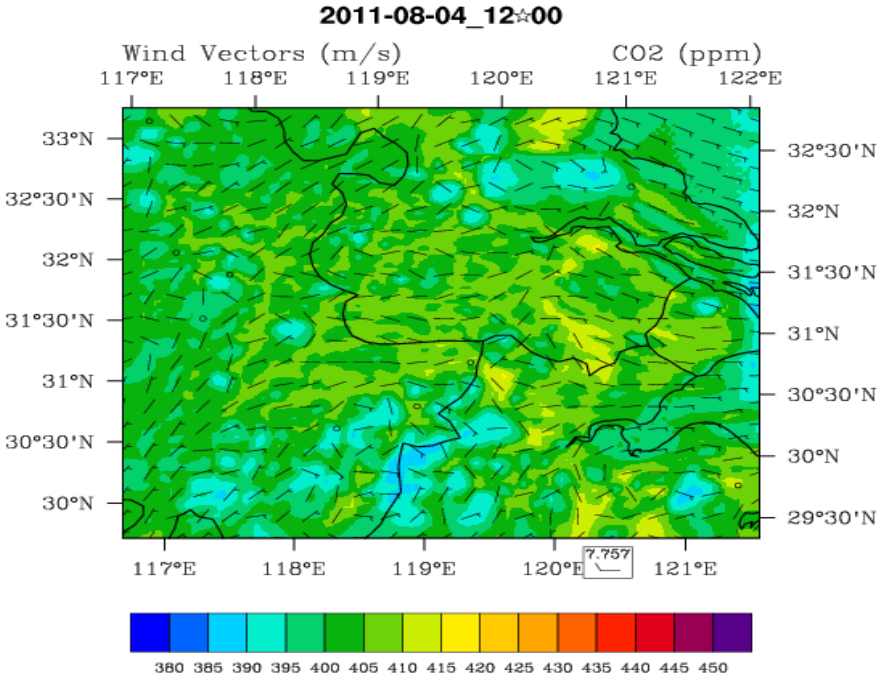
CO_2


2011-08-04_06☆00
Wind Vectors (m/s)
CO2 (ppm)
117°E 118°E 119°E 120°E 121°E 122°E
33°N 32°30'N 32°N 31°30'N 31°N 30°30'N 30°N
32°30'N 32°N 31°30'N 31°N 30°30'N 30°N 29°30'N
117°E 118°E 119°E 120°E 121°E
7.257
380 385 390 395 400 405 410 415 420 425 430 435 440 445 450

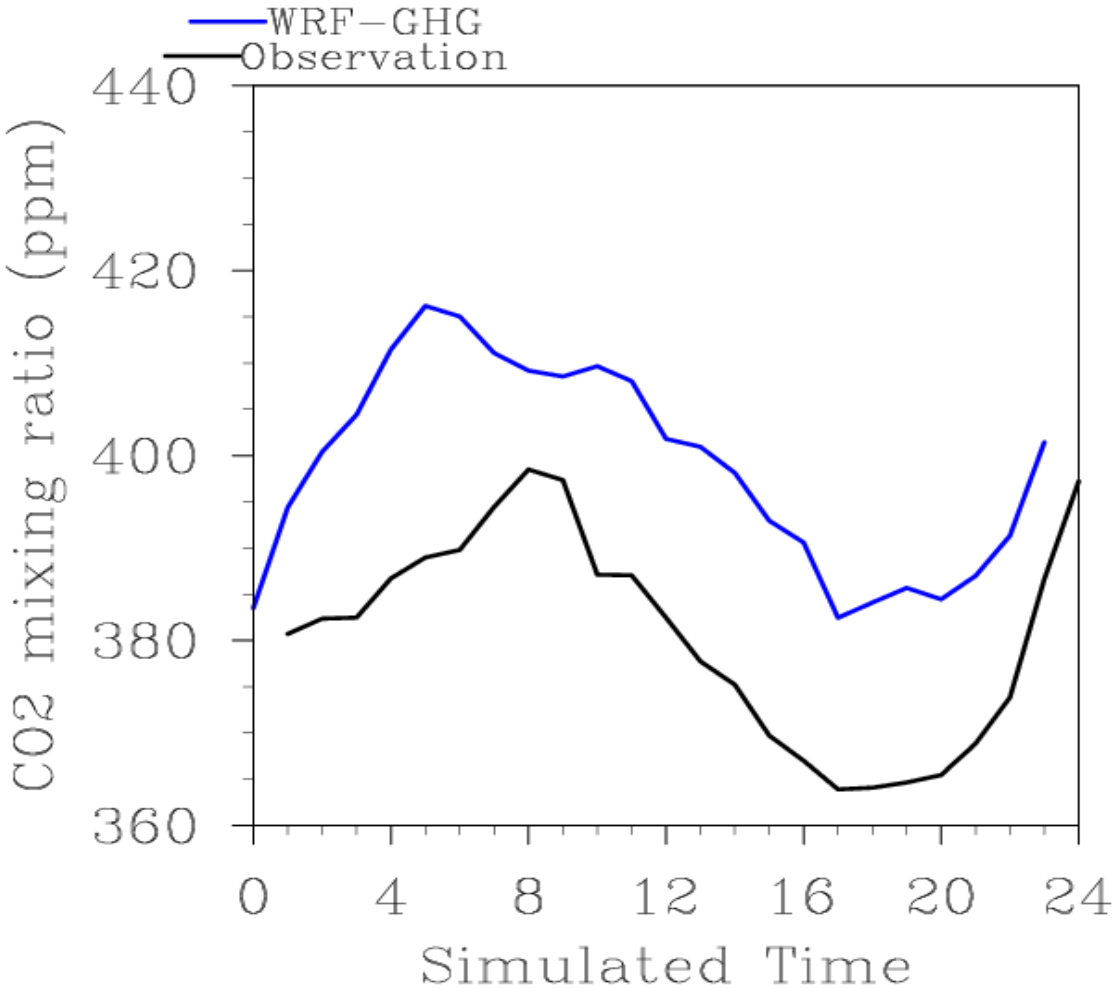
D1

D3


2011-08-04_12☆00
Wind Vectors (m/s)
CO2 (ppm)
95°E 100°E 105°E 110°E 115°E 120°E 125°E
42°N 40°N 38°N 36°N 34°N 32°N 30°N 28°N 26°N 24°N
100°E 105°E 110°E 115°E 120°E 125°E
16.82
380 385 390 395 400 405 410 415 420 425 430 435 440 445 450


2011-08-04_12☆00
Wind Vectors (m/s)
CO2 (ppm)
117°E 118°E 119°E 120°E 121°E 122°E
33°N 32°30'N 32°N 31°30'N 31°N 30°30'N 30°N
32°30'N 32°N 31°30'N 31°N 30°30'N 30°N 29°30'N
117°E 118°E 119°E 120°E 121°E
7.757
380 385 390 395 400 405 410 415 420 425 430 435 440 445 450

Comparison of simulation with observation



August-03-2011 for domain 3 (site located at NUIST campus)

Summary

- A green-house gas module has been coupled with WRF/Chem v3.3.
- One-day testing shows that the WRF-GHG is able to capture the diurnal and spatial variations in CO_2 at regional scale as compared to surface measurement.
- The simulations will be improved further by utilizing more reasonable inputs (e.g., fluxes, ICs, and BCs). This should be done before kick out long-term simulations.

On-going work: VPRM preprocessor

- Source code: Pre_chem_sources
- Input: MODIS satellite data

  (MOD 09A1 Surface Reflectance 8-Day L3, Global 500 m SIN Grid)
- Output:

  Land Surface Water Index (LSWI), LSWIMAX, LSWIMIN

  Enhanced Vegetation Index (EVI), EVIMAX, EVIMIN

  Vegetation fraction:VEGFRA_VPRM

Next steps

- To test WRF-GHG on simulating CH_4
- To evaluate model performance on long-term simulations of CO_2 and CH_4
- To examine the roles of anthropogenic and biogenic emissions in the change of GHG (sensitivity study)
- To perform inverse analysis on evaluating the GHG control strategies