Study on GHG Spatial Distribution and Climate Change Impact in China

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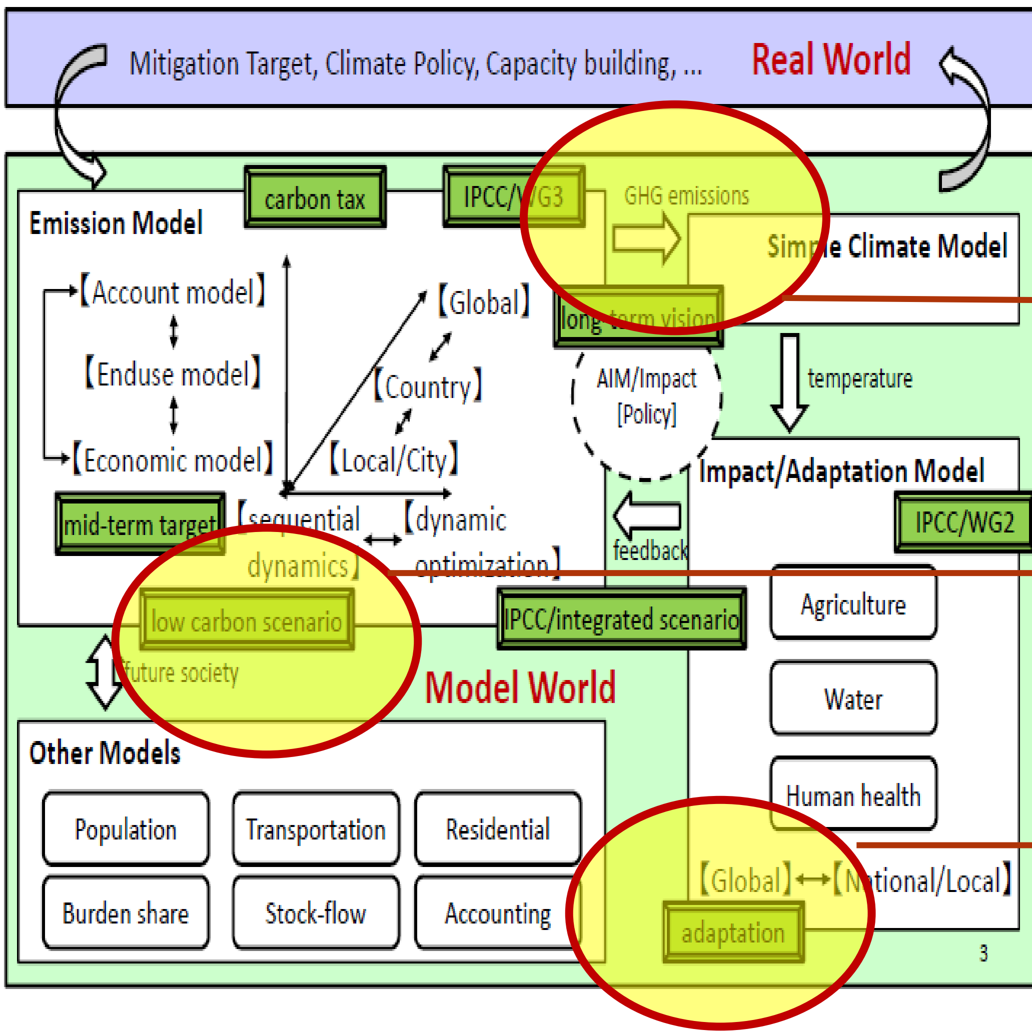
2012.2.18

Background

- Our Group leader, Prof. Sun Jiulin
  - Study the climate change on water resource and agriculture yield more than 10 years.
  - Expand the research area in near years, e.g., cover the GHG retrieval based on remote sensing, ecosystem effect simulation and agriculture adaption measurement faced to global change, etc.

- A new center was established in 2009. Many young scientists joined into our group.
  - Earth System Science Information Sharing Center, IGSNRR, CAS
  - Hosting 2 national platform for data archiving and sharing. One is Earth System Science Data Sharing Platform under NSTI, Another is Data Archiving Center for program research data under MOST.

Background



NIES,2012

GHG retrieval and scenarios simulation technologies

- Story 1:Greenhouse gas concentration distribution retrieval based on remote sensing
- Story 2:Simulating ecological effects for future climate and LUCC scenarios
- Story 3:Winter wheat yield effect analysis and its adaptation measurement in north-west area of Shandong Province, China

Story 1

Study on GHG concentration retrieving and its distribution in China

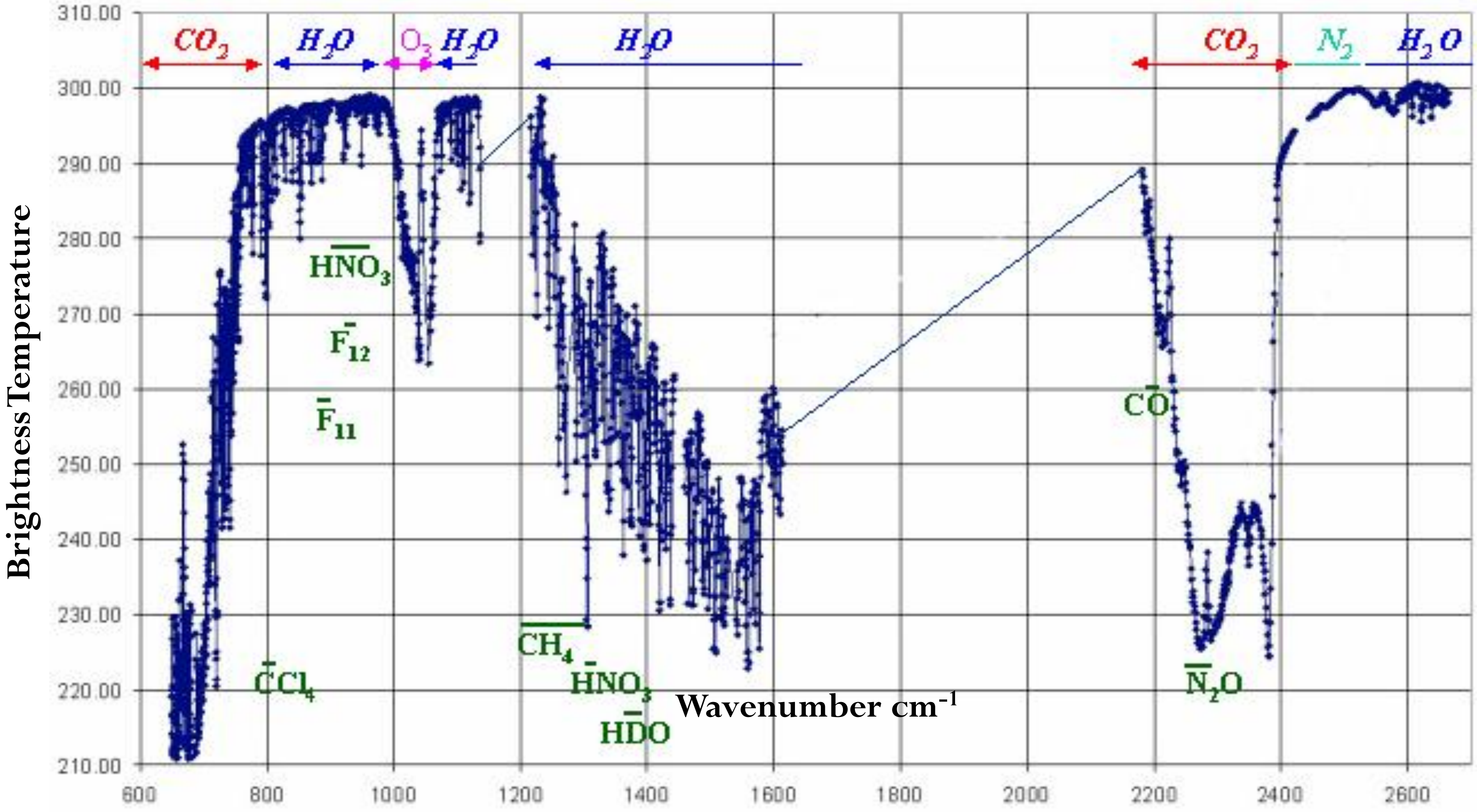
1. Retrieving greenhouse gases from AIRS observations

2378 Channels

$$\lambda / \Delta\lambda = 1200$$

AIRS infrared spectrum

3.7-15.4 μm
650-2665 cm^{-1}



Inversion Solutions

Estimate methane concentration from Atmospheric Infrared Sounder (AIRS) satellite data.

AIRS, an advanced sounder containing 2378 infrared channels and four visible/near-infrared channels, aimed at obtaining highly accurate temperature profiles within the atmosphere plus a variety of additional Earth/atmosphere products.

All raw-level AIRS data up to 40 TB have already been archived in Information Center, IGSNRR

- 1. From Artificial Neural Network

  Cloud screen to obtain clear-sky signal

  Singular value decomposition to compress data

  Feed-forward three-layer perception function

  Bayesian regulation, Early stopping, Cost-function to optimize ANN model

To directly estimate the distribution of methane at the surface

- 2. From Radiative Transfer Model simulation

$$V(v) = \phi(v) * \left\{ I_0(v) K_1 \tau_a(v) \tau_o(v) \tau_{ms}(v) \times \exp\left[-\int_0^\infty \sigma(v,z) q \rho_0(z) \Sigma(z) M(\theta) dz \right] \right\}$$

$$V(v) = C\phi(v) * \left\{ \exp\left[-\int_0^\infty \sigma(v,z) q \rho_0(z) \Sigma(z) M(\theta) dz \right] \right\}$$

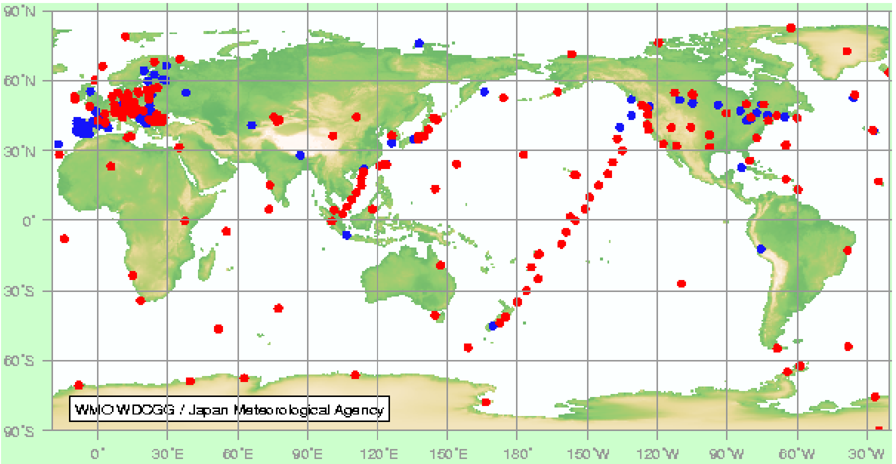
$$R(v) = \frac{V(v)}{V(v_0)} = \frac{\phi(v) * \tau(v)}{\phi(v_0) * \tau(v_0)}, \quad \tau(v) = \exp\left[-\int_0^\infty \sigma(v,z) q \rho_0(z) \Sigma(z) M(\theta) dz \right]$$

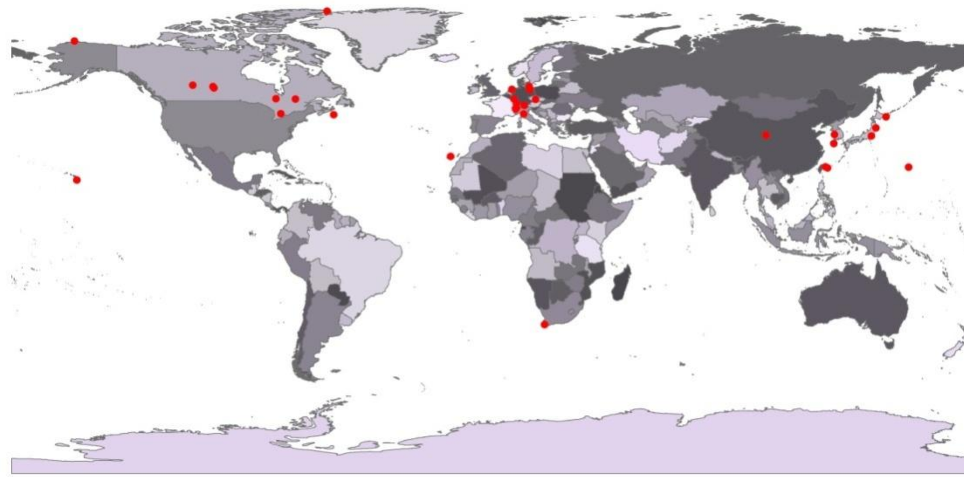
$$W_{CH4} = \int_0^\infty q_{CH4} \Sigma_{CH4}(z) \rho_0(z) dz = q_{CH4} \int_0^\infty \Sigma_{CH4}(z) \rho_0(z) dz$$

σ: is absorption coefficient;
ρ: atmospheric density profile;
Σ: initial vertical mixing ratio; M: air mass;
q: Scale factor.

Line by Line model with HITRAN 2008 for gas absorption

Input Data for ANN model



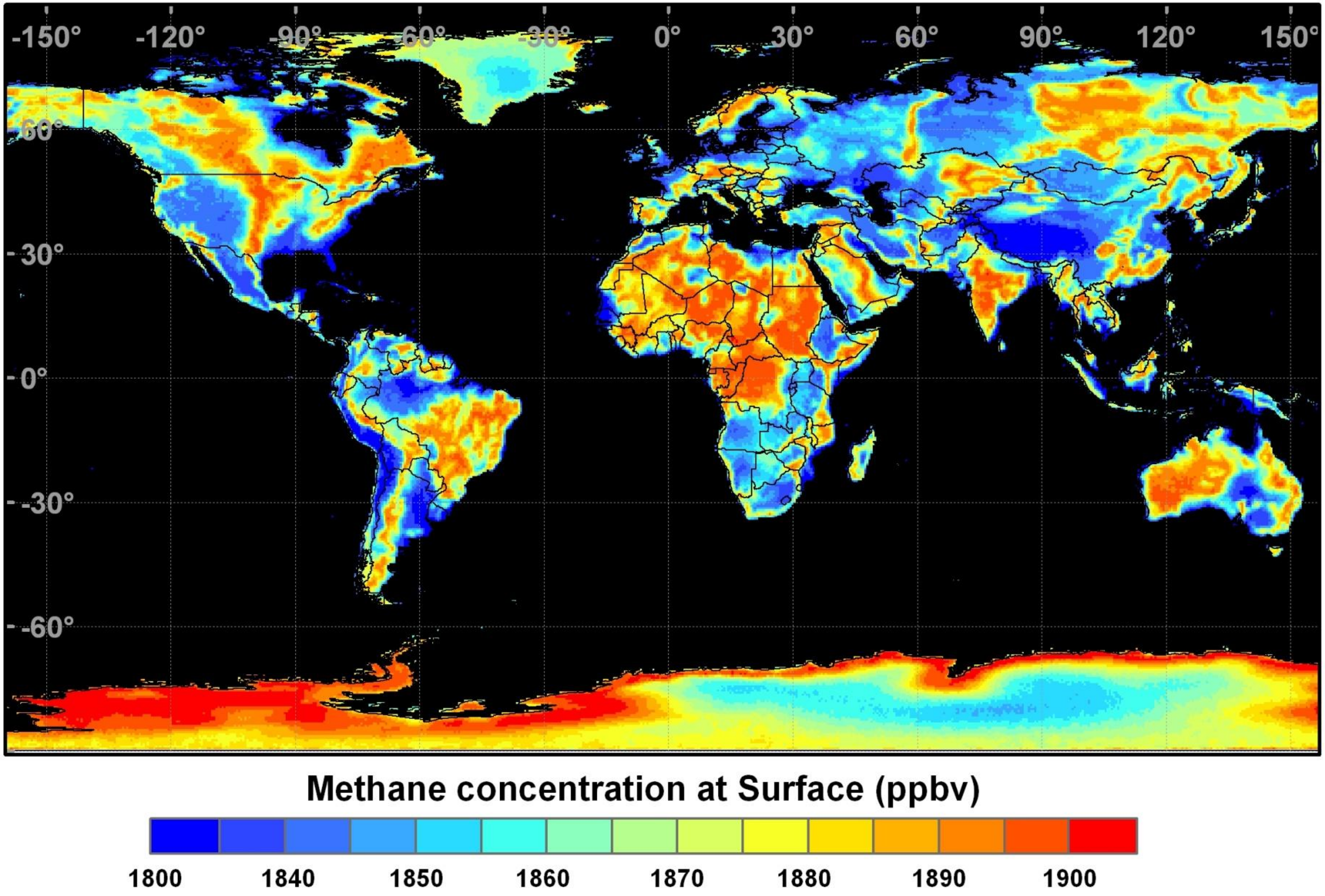


The fixed stations that contribute data to the World Data Centre for Greenhouse Gases (WDCGG). The symbol " • " denotes that the data from the station has been updated in the last 365 days.

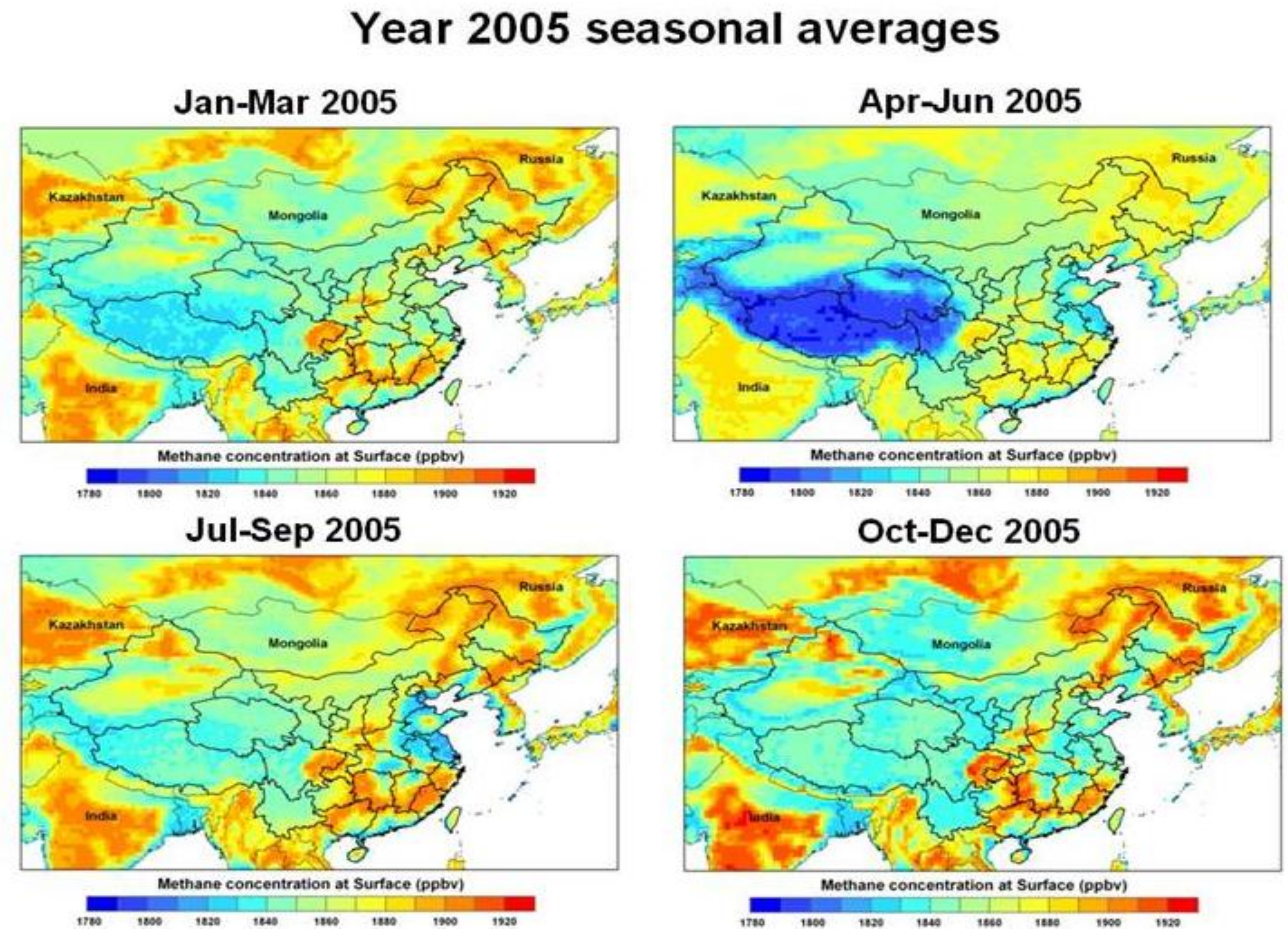
The distribution of stations used in the ANN model inversion.

These stations measure high frequency ambient methane concentration per day by gas chromatographic method, and provide continuous, relative long-term observations.

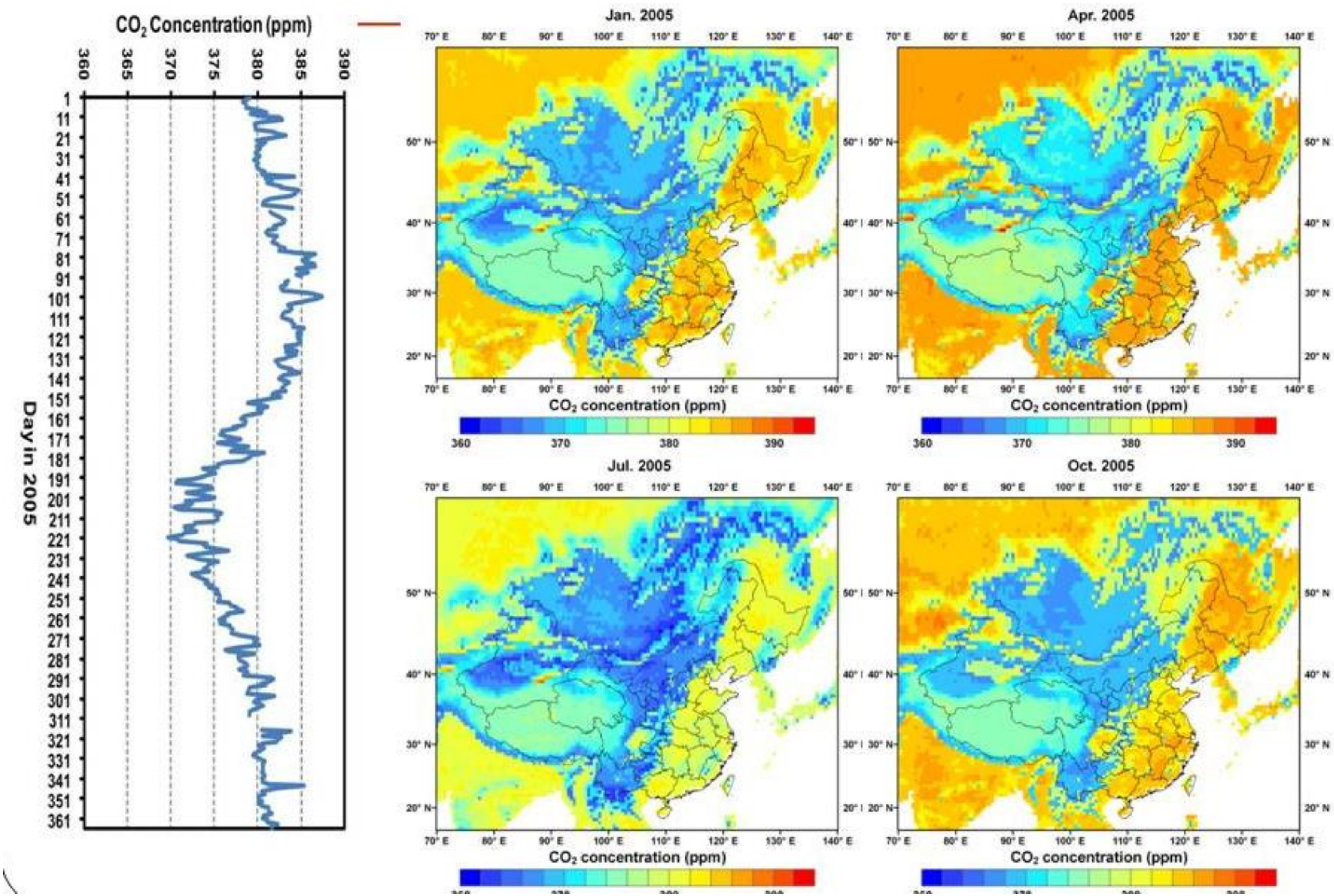
Methane concentration over global land from AIRS – Our method (0.5°)



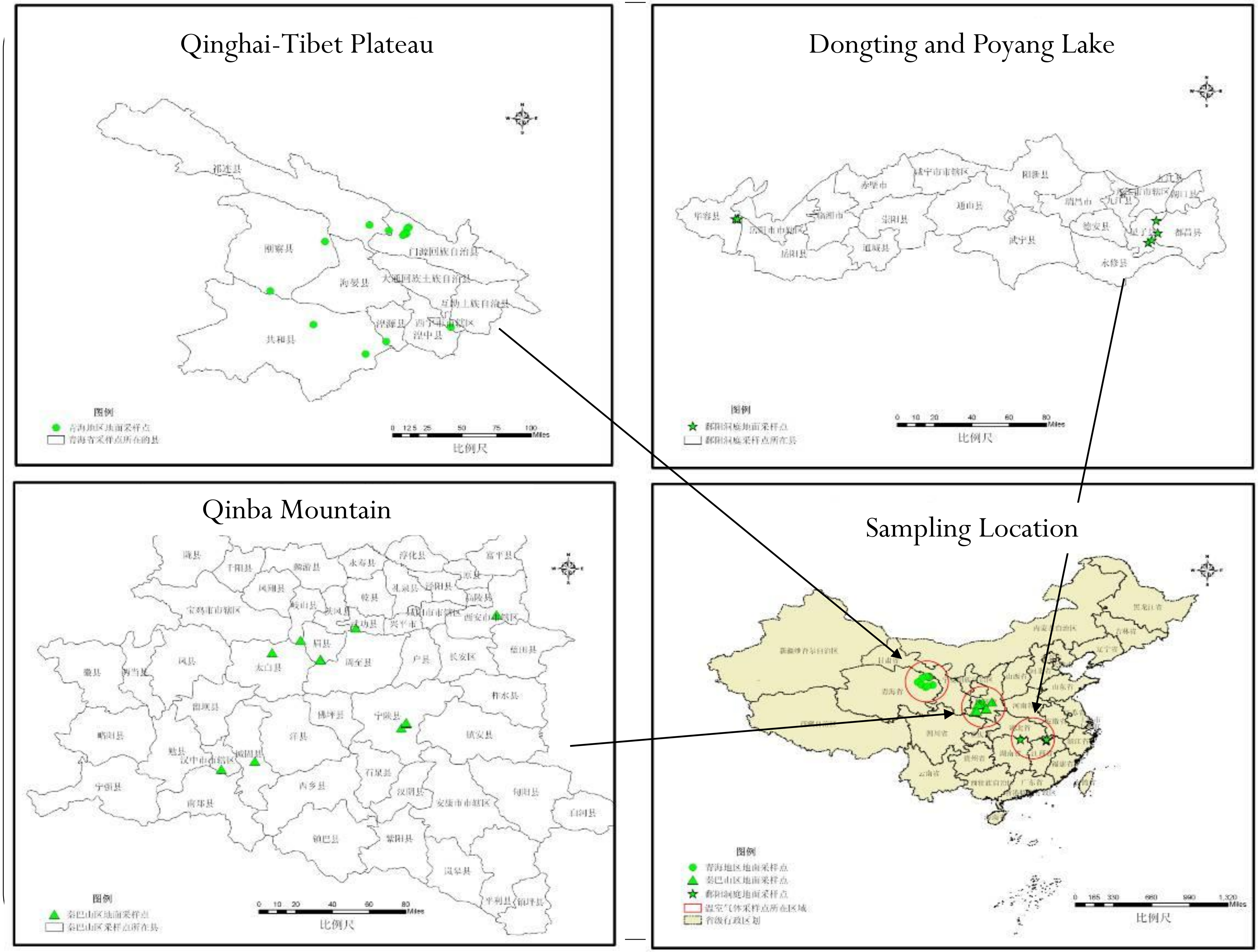
Ch4 Concentration by season in China



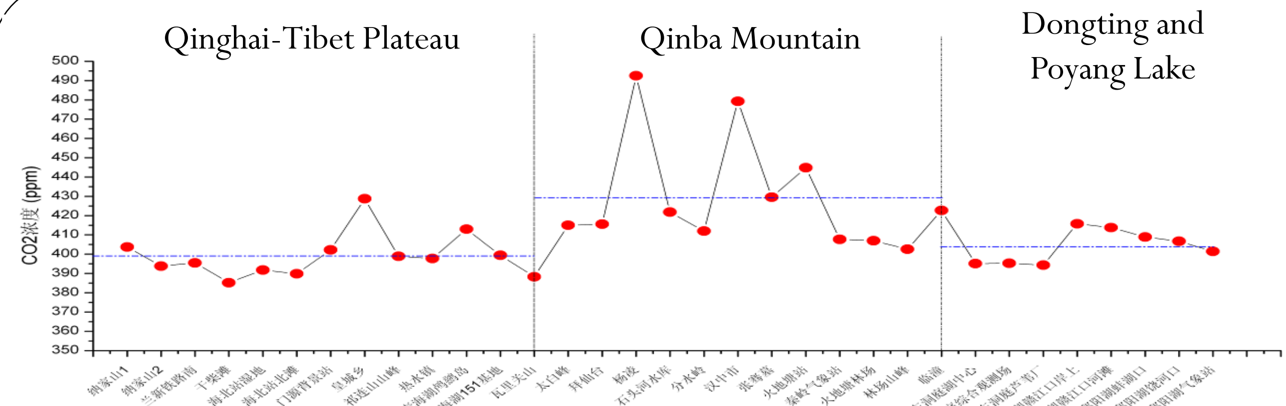
CO_2 Concentration by month in China (2005)

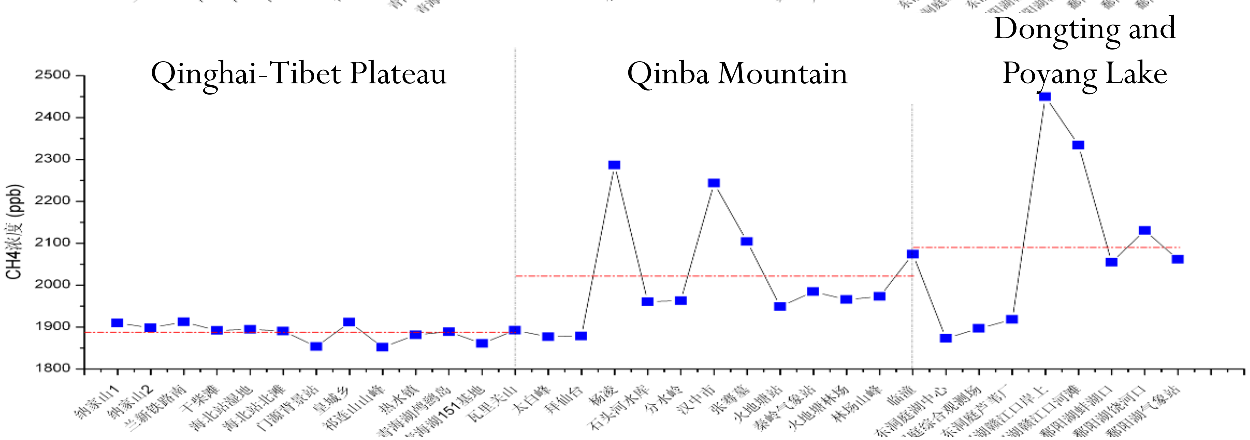


2011.5-9, Ground truth

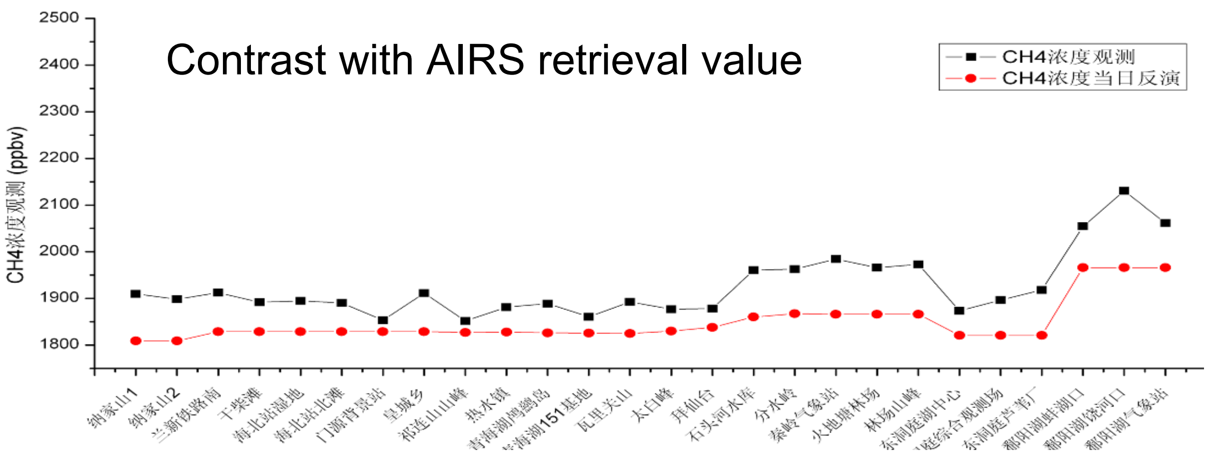


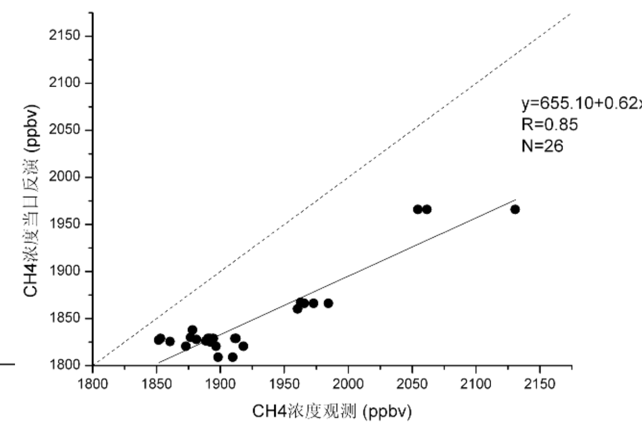
Qinghai-Tibet Plateau
Dongting and Poyang Lake
Qinba Mountain
Sampling Location
图例
比例尺
Miles





<table>
<tr><th rowspan="2">Station</th><th>CO_2</th><th>CH_4</th></tr>
<tr><th>Relative Error</th><th>Relative Error</th></tr>
<tr><td>WLG</td><td>2.1%</td><td>1.3%</td></tr>
<tr><td>NJS</td><td>5.6%</td><td>2.0%</td></tr>
</table>

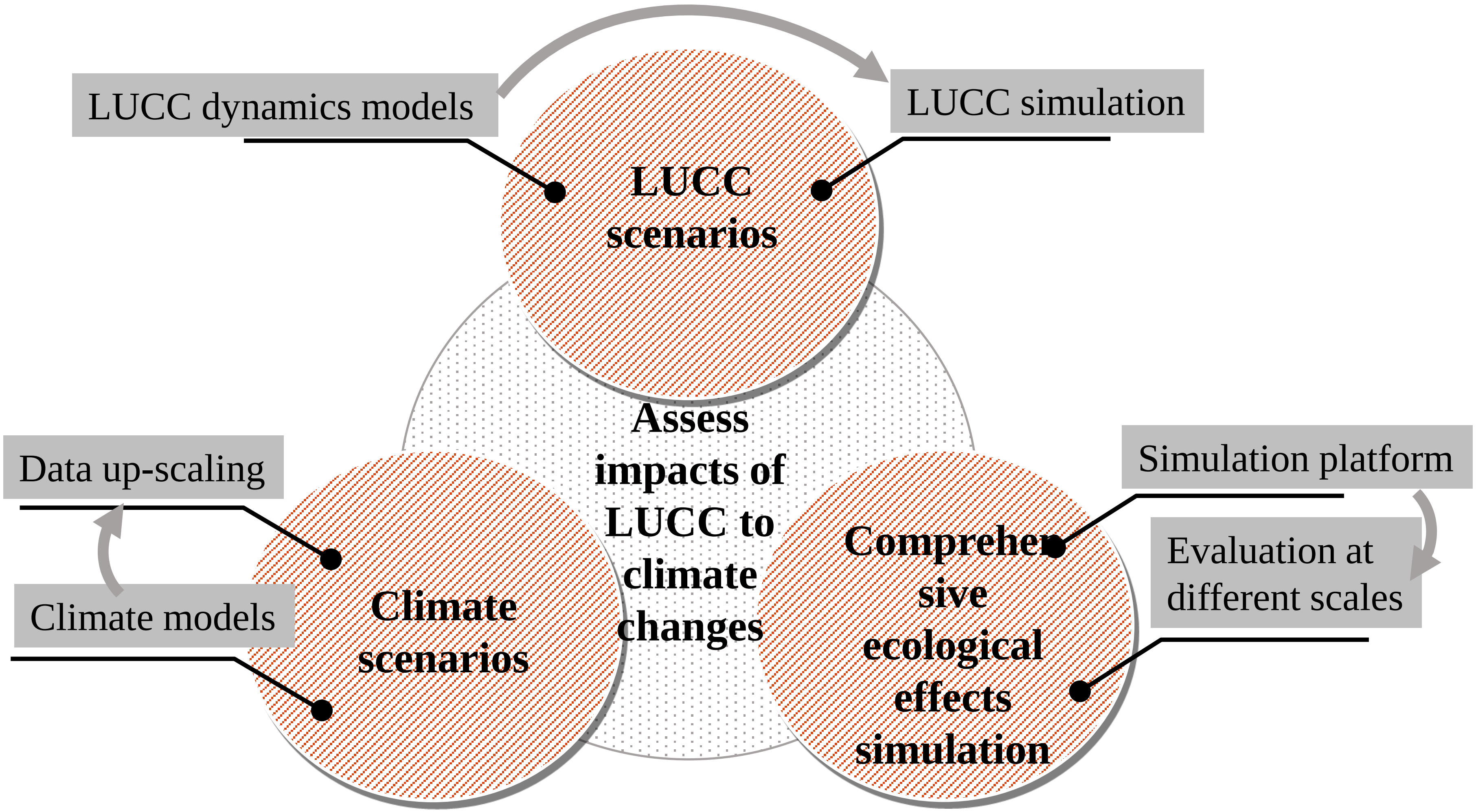




Story 2

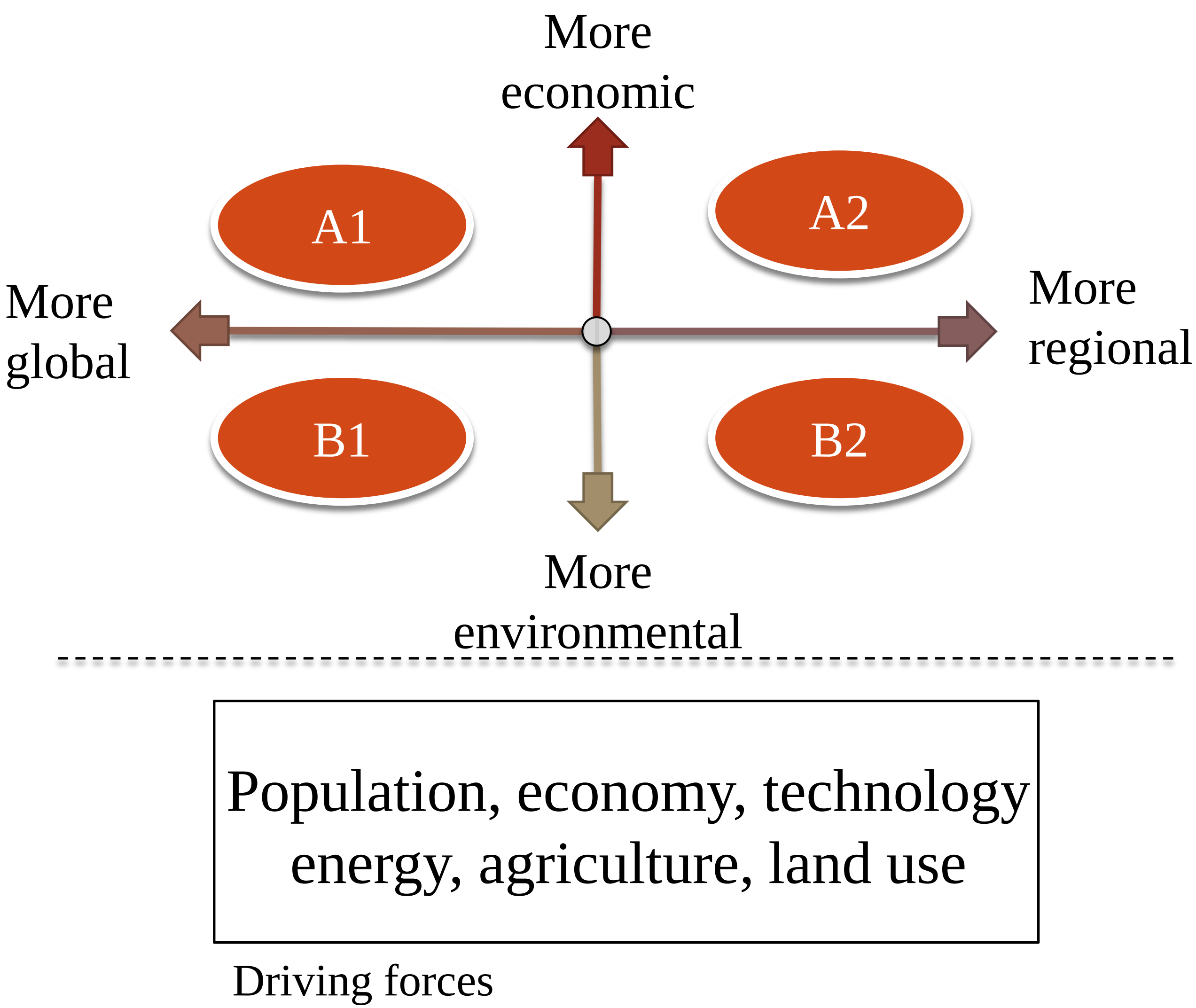
Simulating ecological effects for future climate and LUCC scenarios

Simulate land surface energy balances and evaporation for regions with different dominating land cover types in China using the EASS (Ecosystem-Atmosphere Simulation Scheme) model



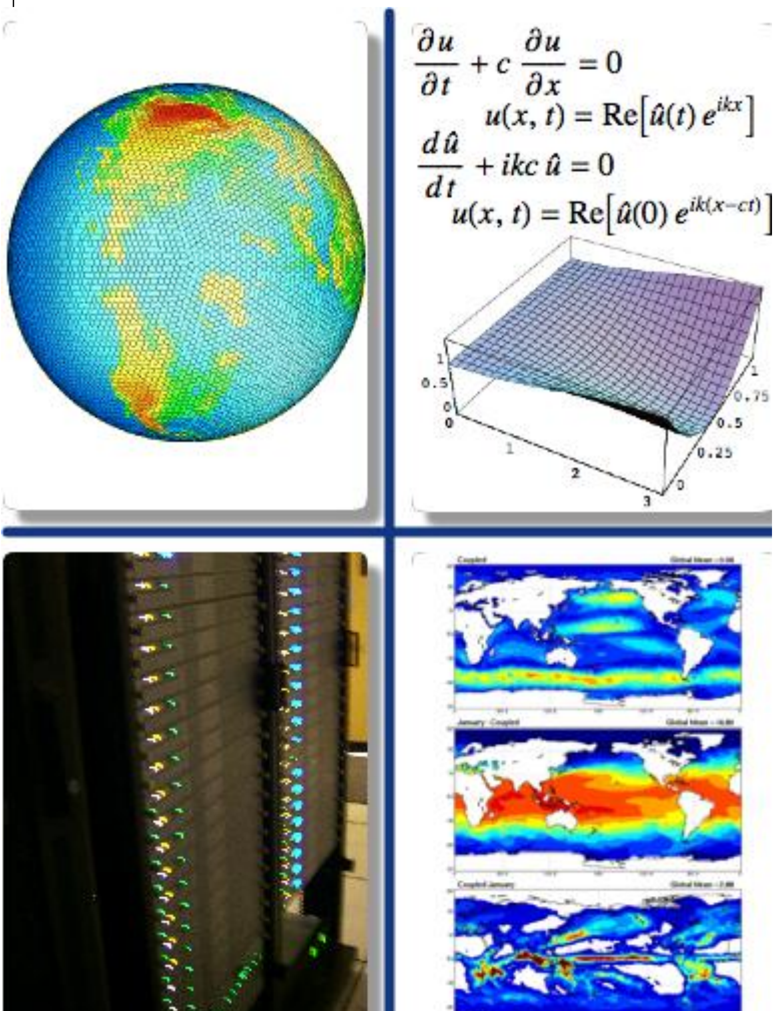
Chen, B., J. M. Chen, et al. (2007). "Remote sensing-based ecosystem–atmosphere simulation scheme (EASS)—Model formulation and test with multiple-year data." *Ecological Modelling* **209: 277-300.**

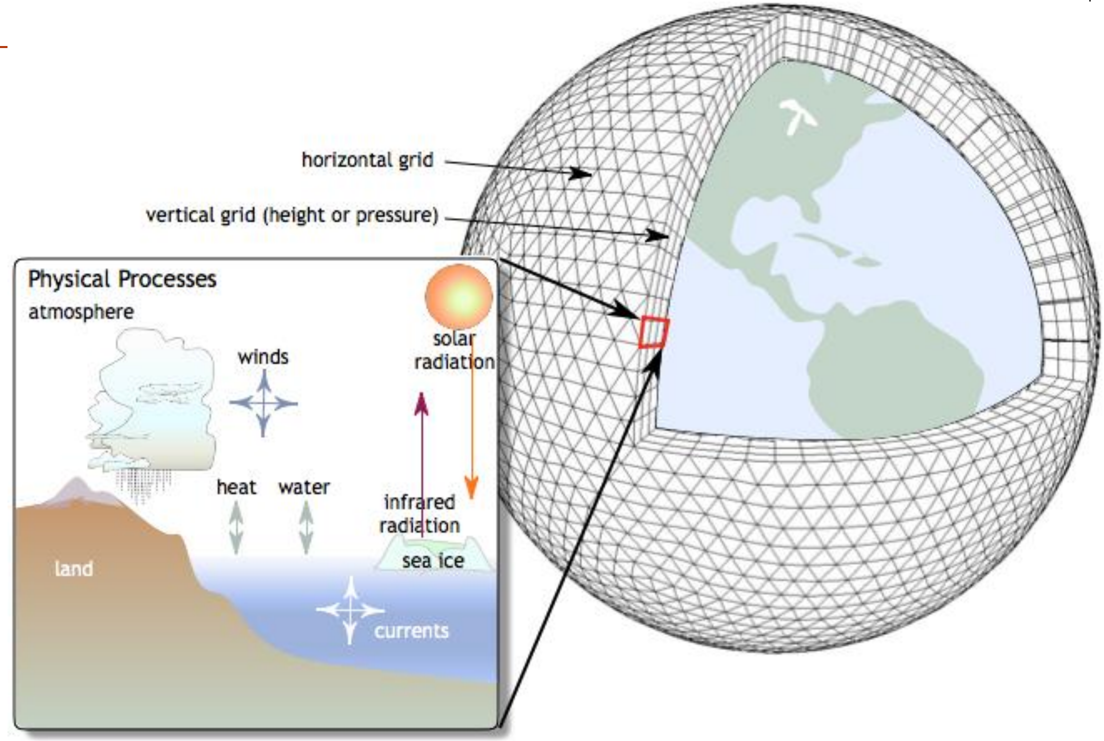
IPCC SRES scenarios and driving forces



Nakicenovic et al. (2000)

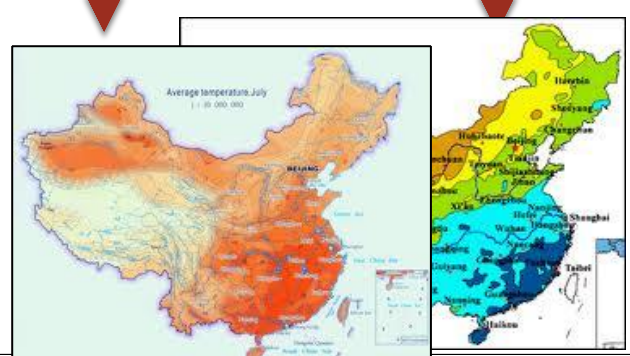
A General Circulation Model (GCM) is a mathematical model of the general circulation of a planetary atmosphere or ocean.



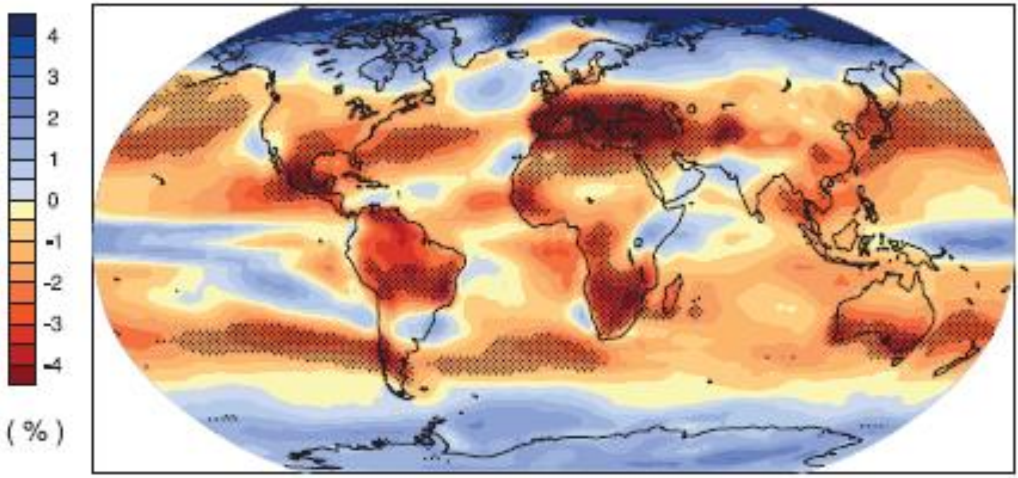


Down-scaling

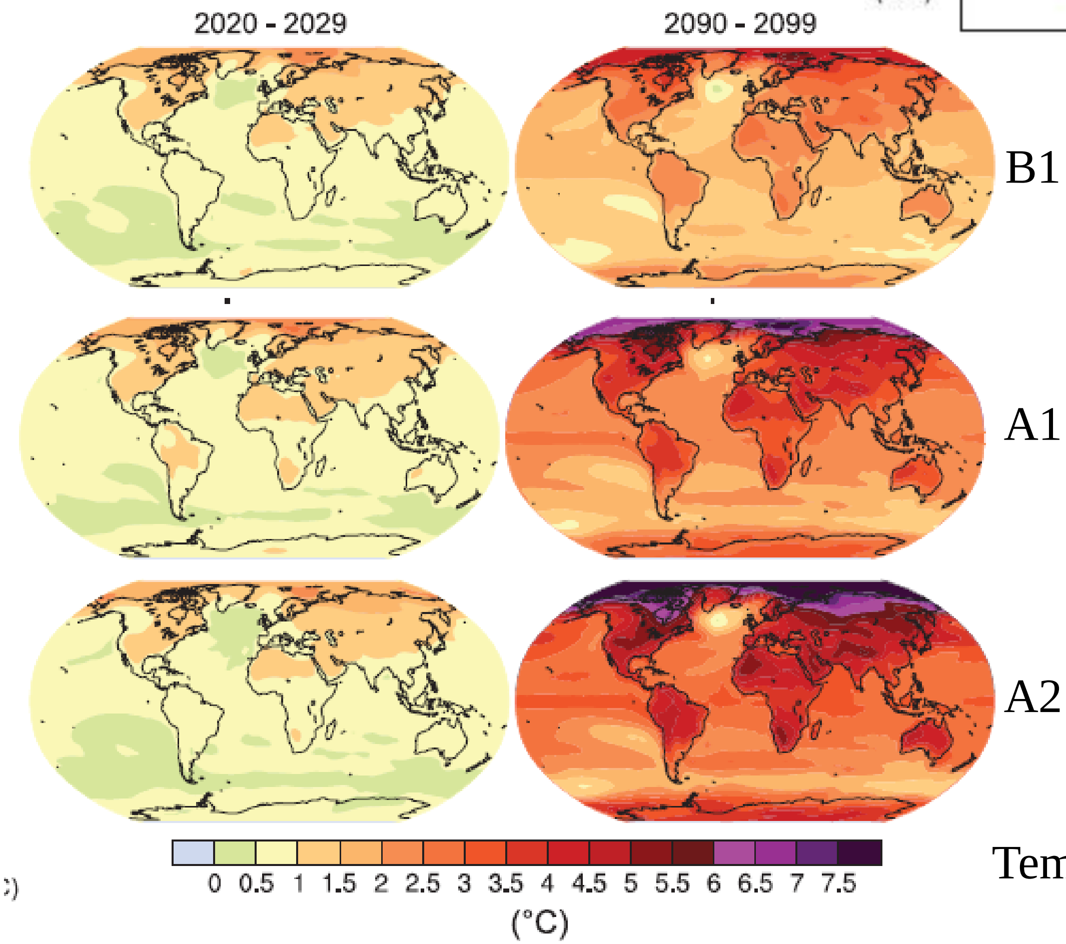
Regional climate model（RCM）



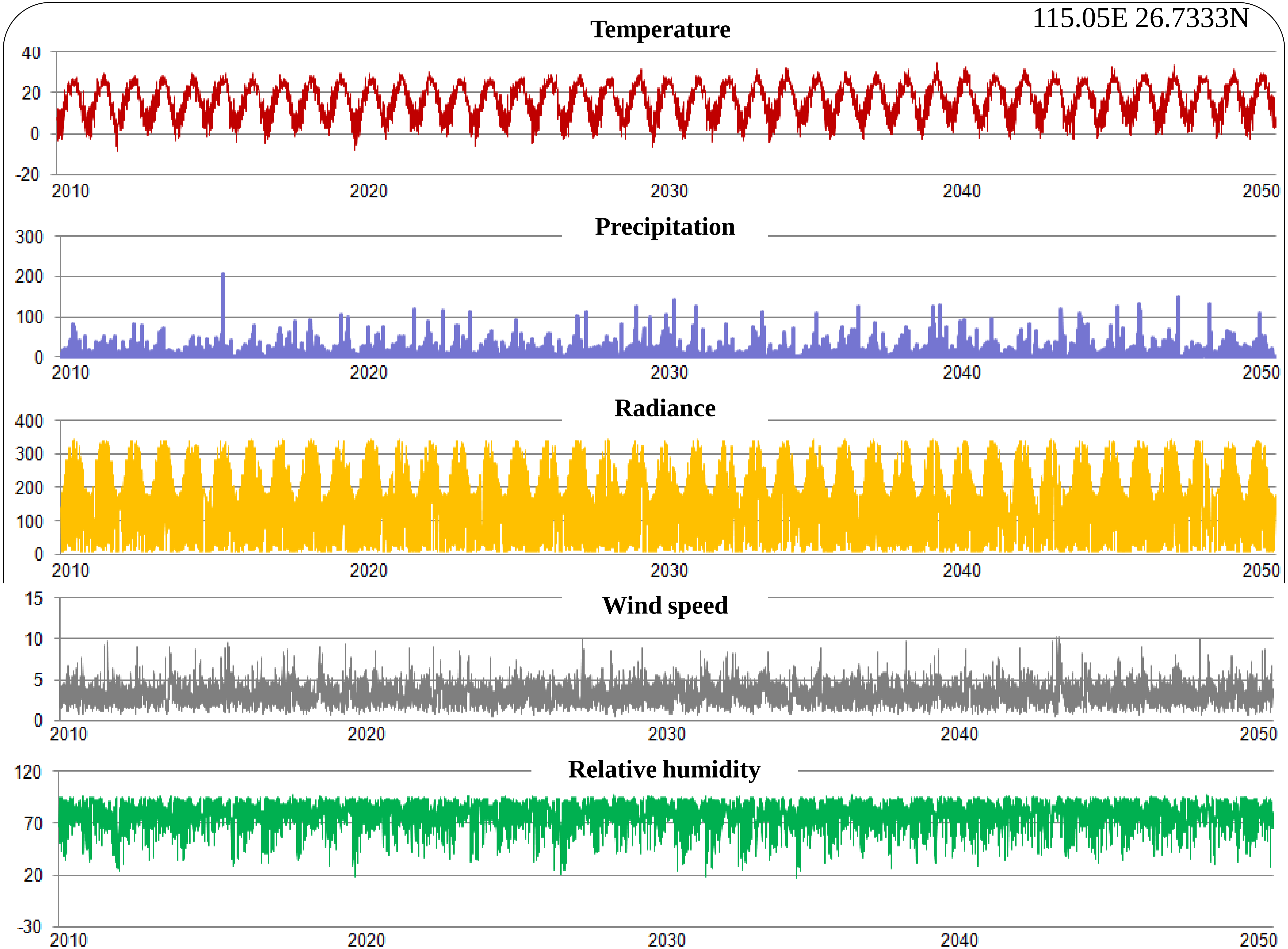
A GCM can be used for simulating climate elements for different climate scenarios



Precipitation distribution

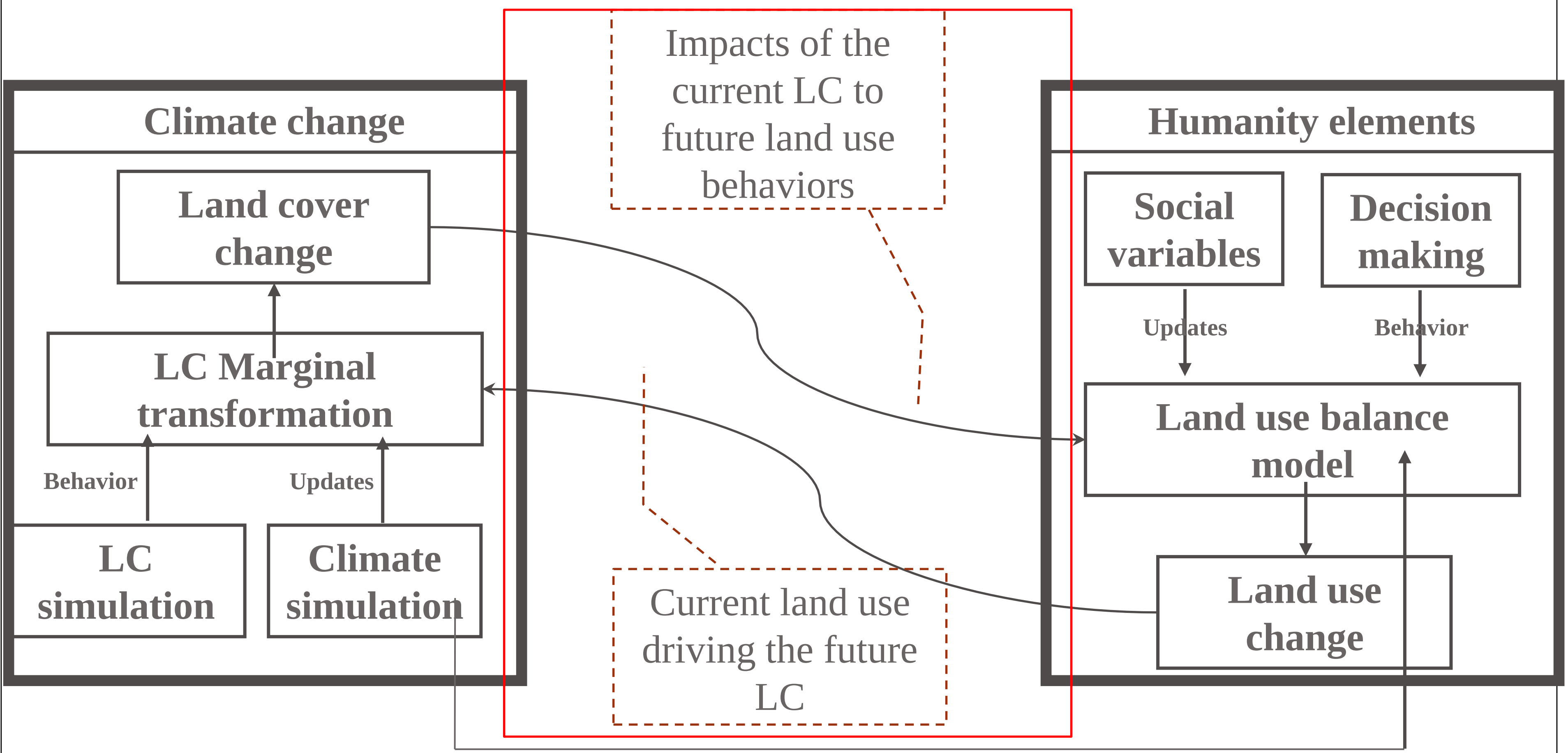


Temperature changes



115.05E 26.7333N
Temperature
40
20
0
-20
2010
2020
2030
2040
2050
Precipitation
300
200
100
0
2010
2020
2030
2040
2050
Radiance
400
300
200
100
0
2010
2020
2030
2040
2050
Wind speed
15
10
5
0
2010
2020
2030
2040
2050
Relative humidity
120
70
20
-30
2010
2020
2030
2040
2050

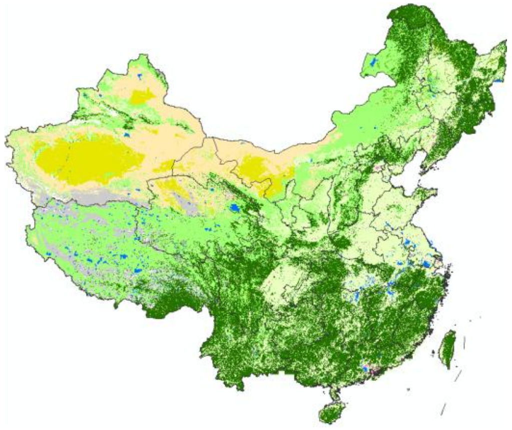
LUCC dynamics (LUCCD) model



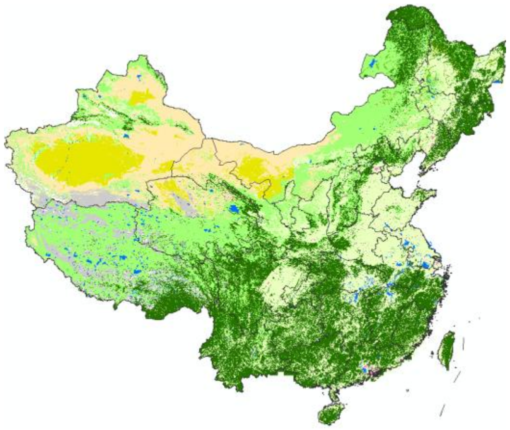
Integrate models that simulating land cover changes derived by climate change, land use change. Land use balance model has been adopted to estimate the interactions between industry and agriculture regions.

Future land cover scenarios

- Simulated land cover scenarios for 2010 ~ 2050
- 3 scenarios：
  - A2 (economic development)
  - B2 (environmental development)
  - GH (following the regional development plans)
- Spatial resolution: 30km



2020 （A2）

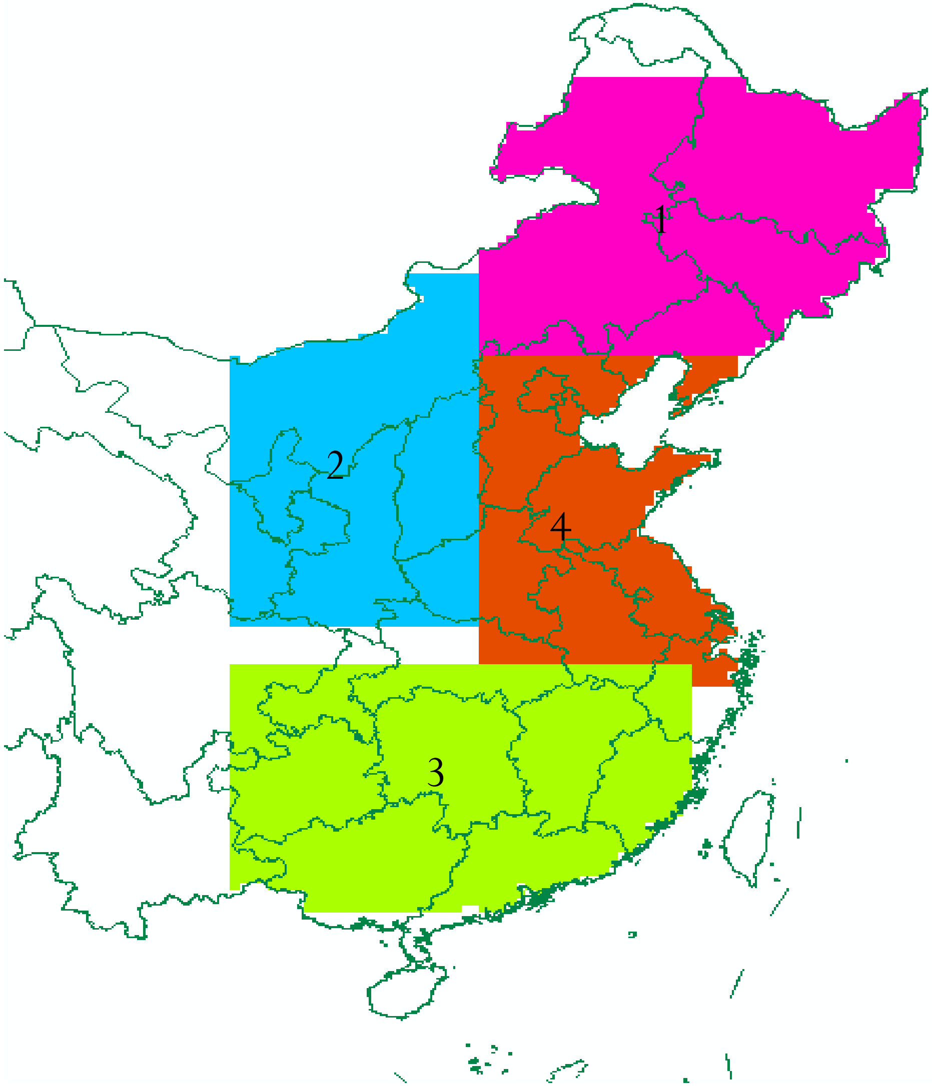


2020 （B2）

Development and applications of integrated land surface process modeling

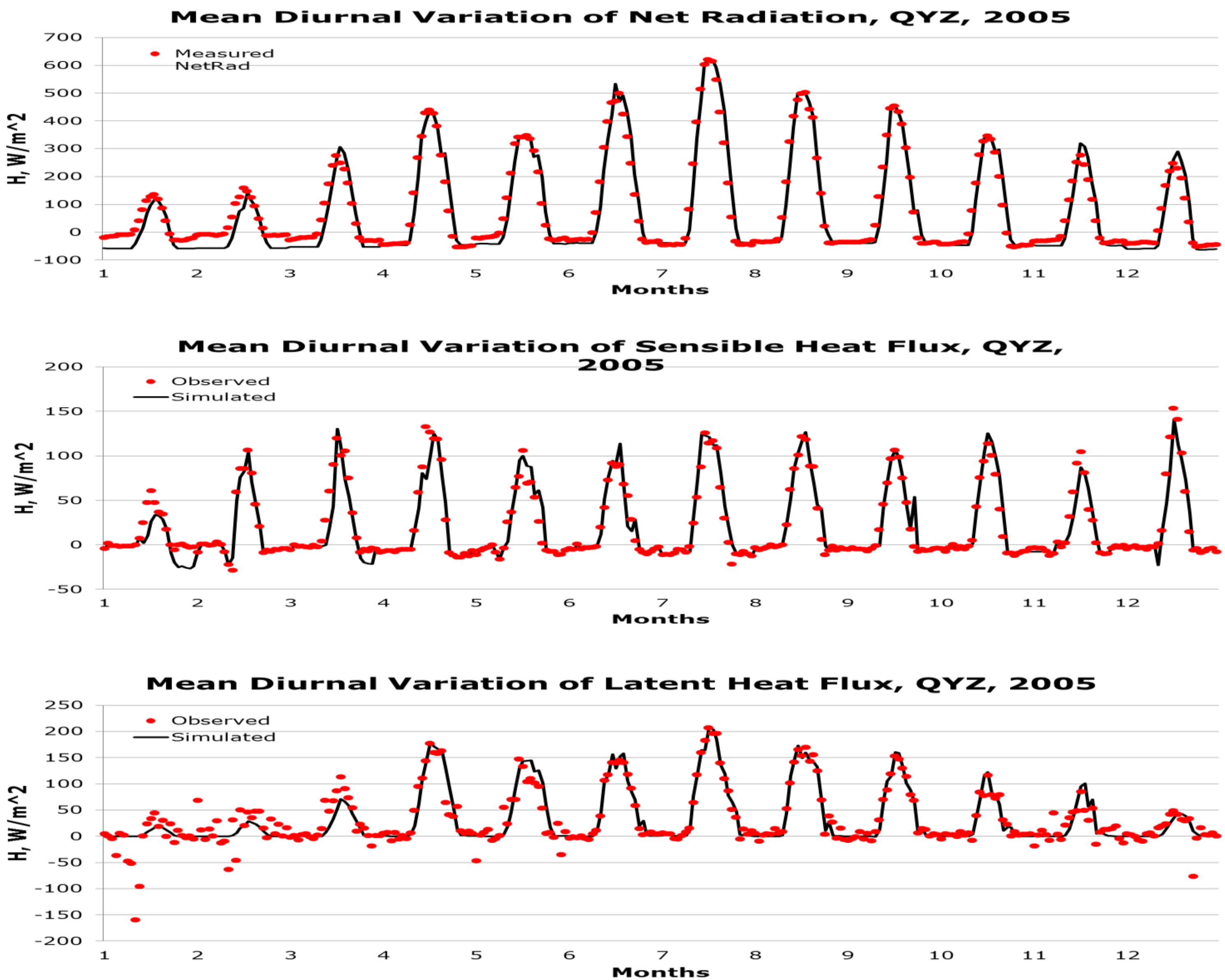
- Develop and optimize the EASS model
- Run EASS in the 4 selected regions in China
- Simulate key land surface water heat flux parameters

➢ ***Team**: B. Chen, M. Feng，S. Fang, J. Yan, et al.*

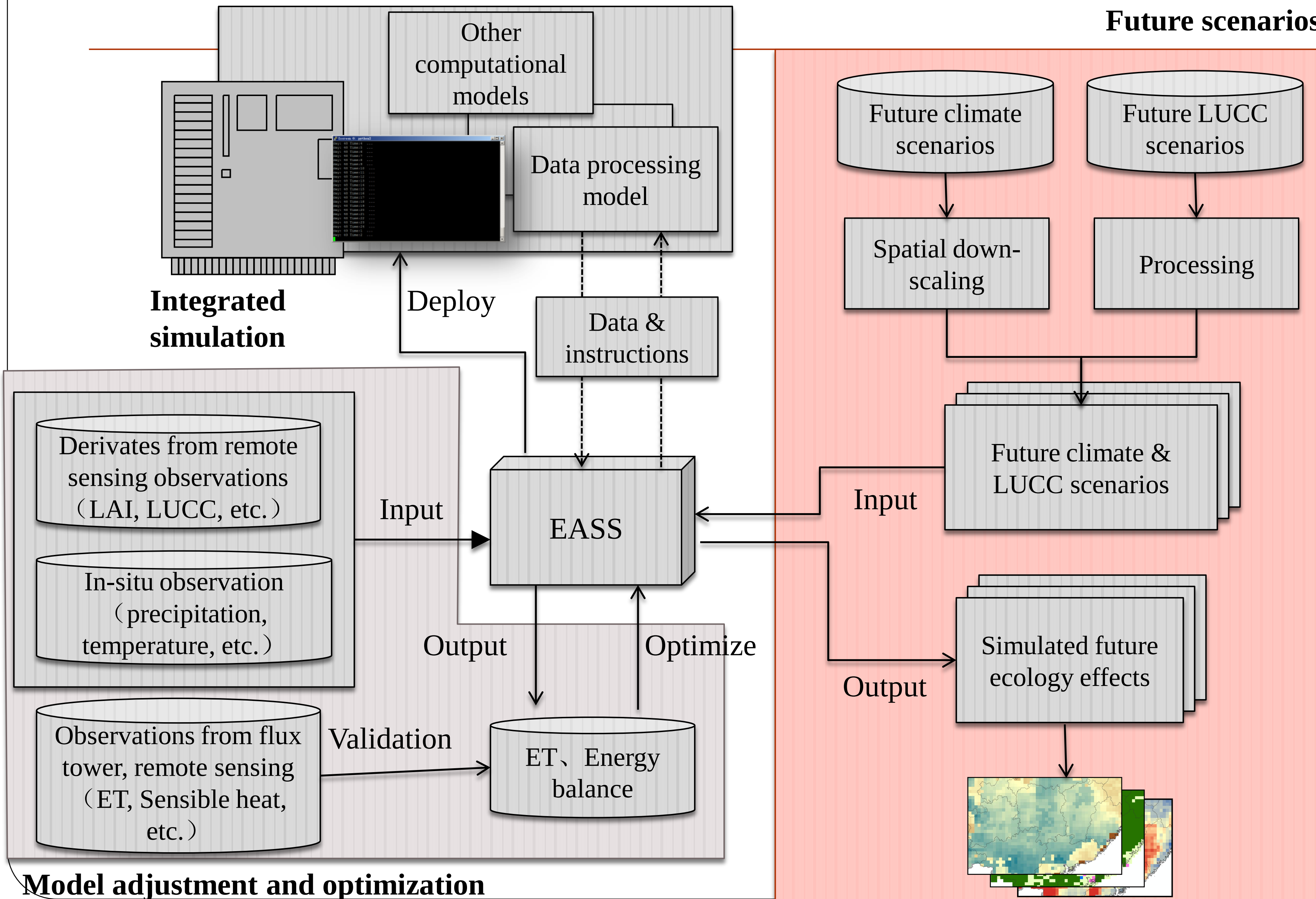


Test and optimize EASS for China

Preliminary evaluation results using in-situ observations at Qianyianzhou, Jiangxi, China (2005)

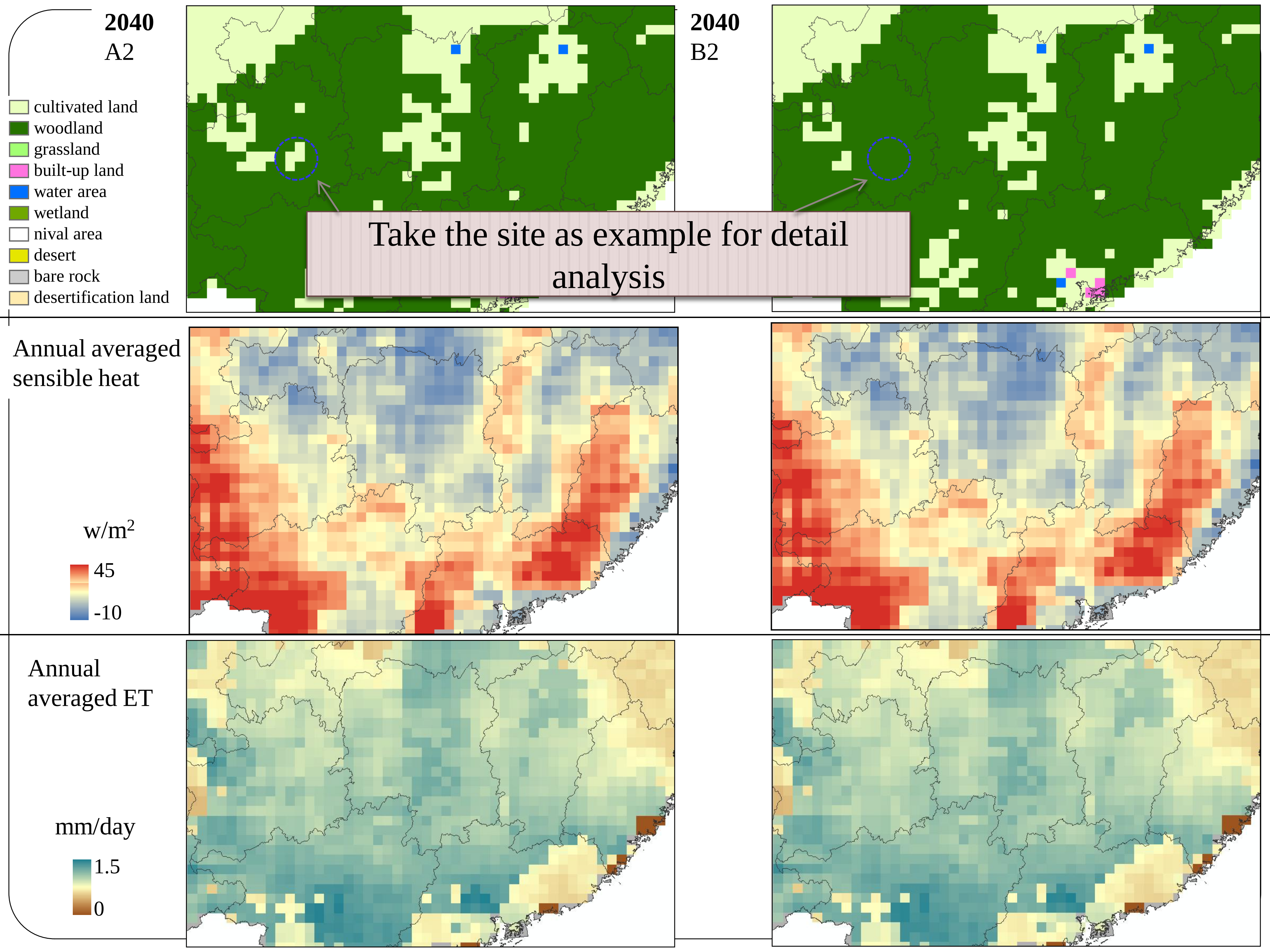


Integrated ecological effects simulation



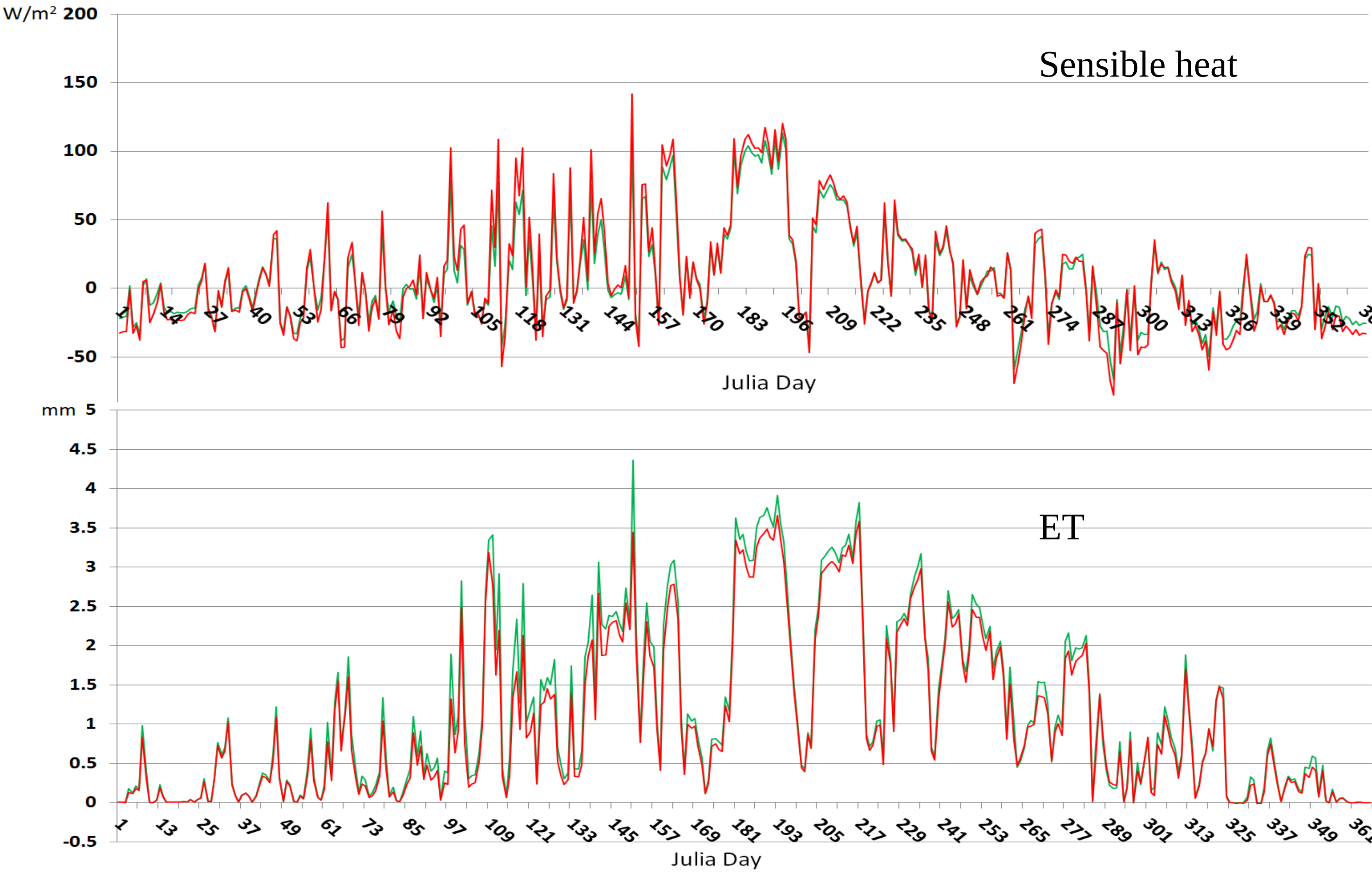
Model simulation results

- Simulated ecological effects in 4 regions with 3 land cover scenarios（A2、B2、GH）for 2010~2050.
- ecological effects elements:
  - Sensible heat
  - Latent heat
  - ET
  - NPP
  - GPP


2040
A2
2040
B2
cultivated land
woodland
grassland
built-up land
water area
wetland
nival area
desert
bare rock
desertification land
Take the site as example for detail analysis
Annual averaged sensible heat
w/m2
45
-10
Annual averaged ET
mm/day
1.5
0

2040_B2
(woodland）

2040_A2
(cultivated land ）



The site is located east to Guiyang. It is predicted as woodland in 2040 in B2 and remain cultivated land in A2. Annual averaged sensible heat for B2 is 9.4% higher than A2; on contrast, ET is 9.4% lower than A2.

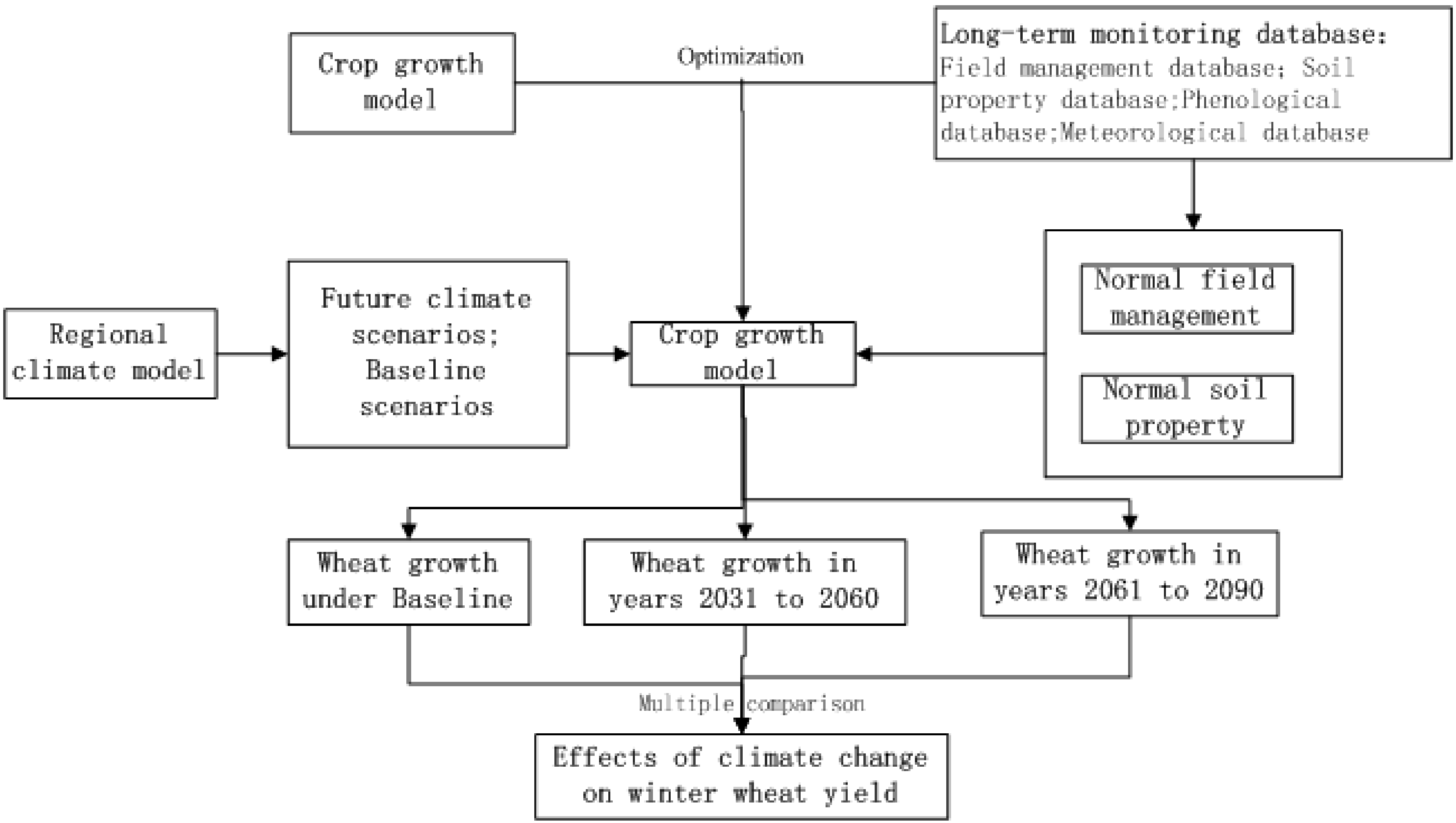
Story 3

Winter wheat yield effect analysis and its adaptation measurement study on north-west area of Shandong Province, China

Objective

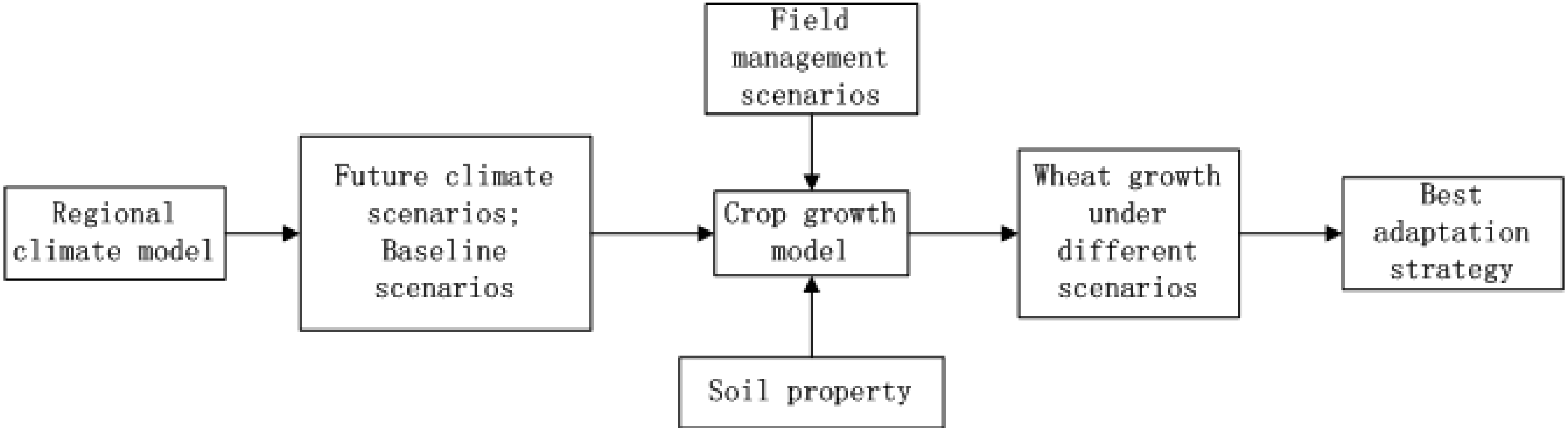
The purpose of this study is to analysis effect of climate change on winter wheat yield and to give some appropriate adaptation strategies for field management under A1B climate change scenario in northwest of Shandong province, by combining regional climate model and crop growth model.

Material and methods



Framework for studying on effect of climate change on winter wheat production

Material and methods

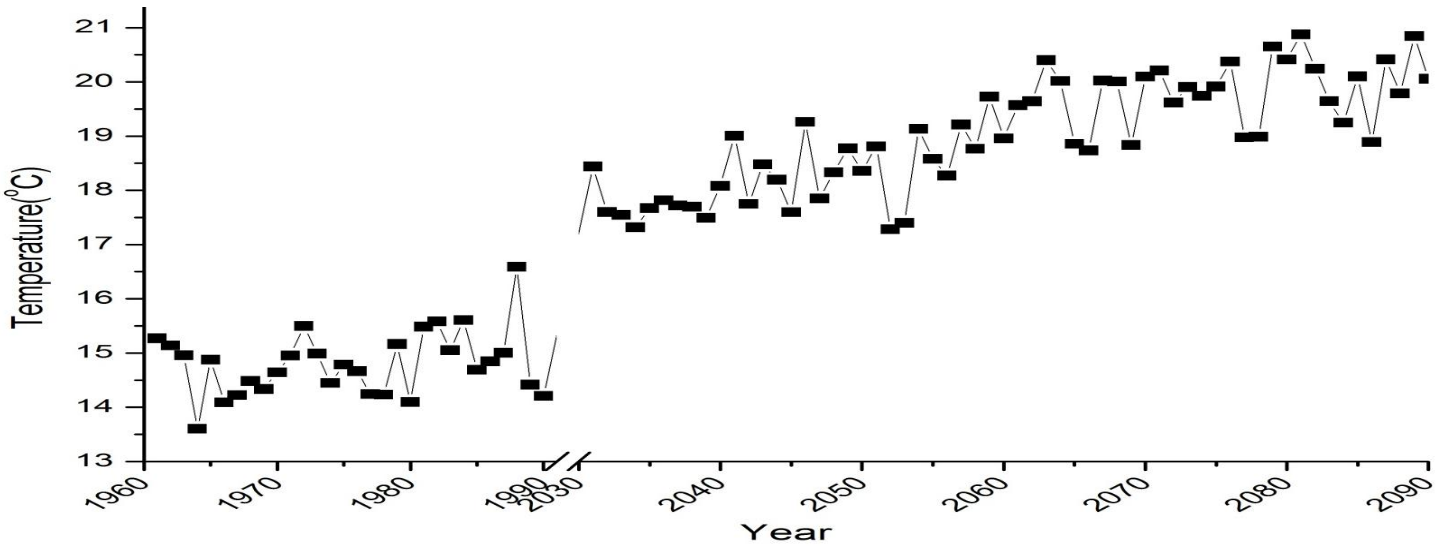


Framework for studying on field adaptation strategy with considering climate change

Results and analysis

- **Change of climate resources(under A1B)**

— Heat resources



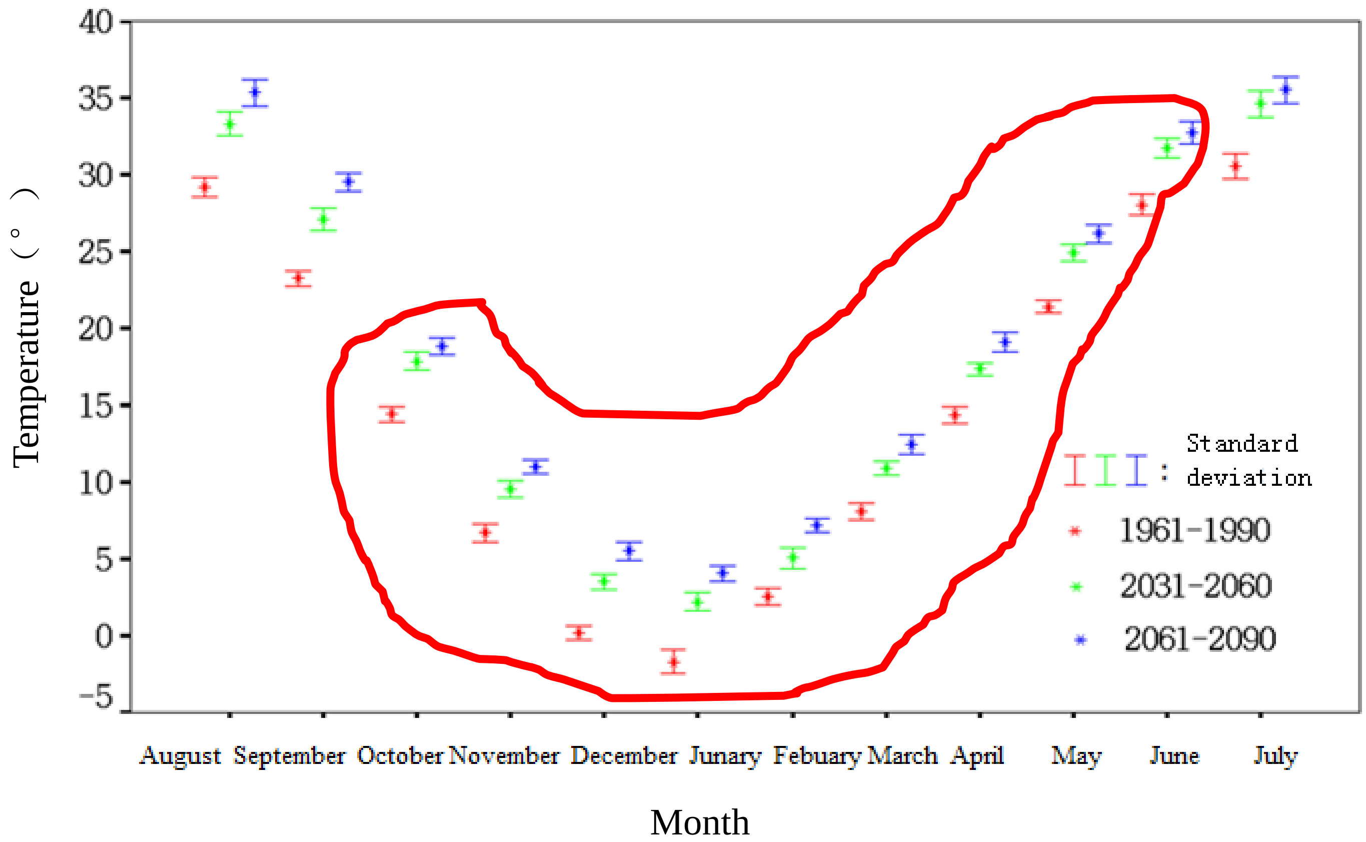
	Average temperature#	Maximum temperature	Minimum temperature
1961-1990	14.81[a]（0.04*）	20.75[a]（0.06）	8.86[a]（0.04）
2031-2060	18.24[b]（0.04）	24.24[b]（0.03）	12.23[b]（0.05）
2061-2090	19.84[c]（0.03）	25.79[c]（0.03）	13.88[c]（0.04）

*： Brackets for the coefficient of variation;#:Different letters means significant at 0.05 level

Results and analysis

- **Change of climate resources(under A1B)**

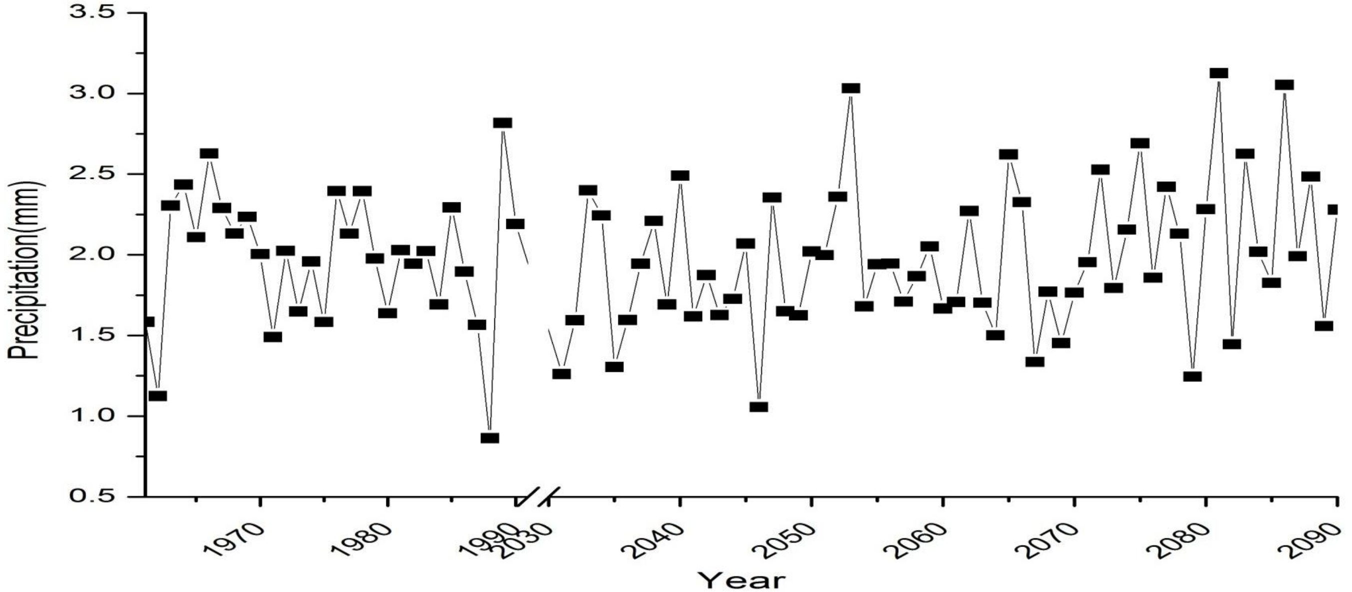
— Heat resources



Results and analysis

- **Change of climate resources(under A1B)**

— Precipitation



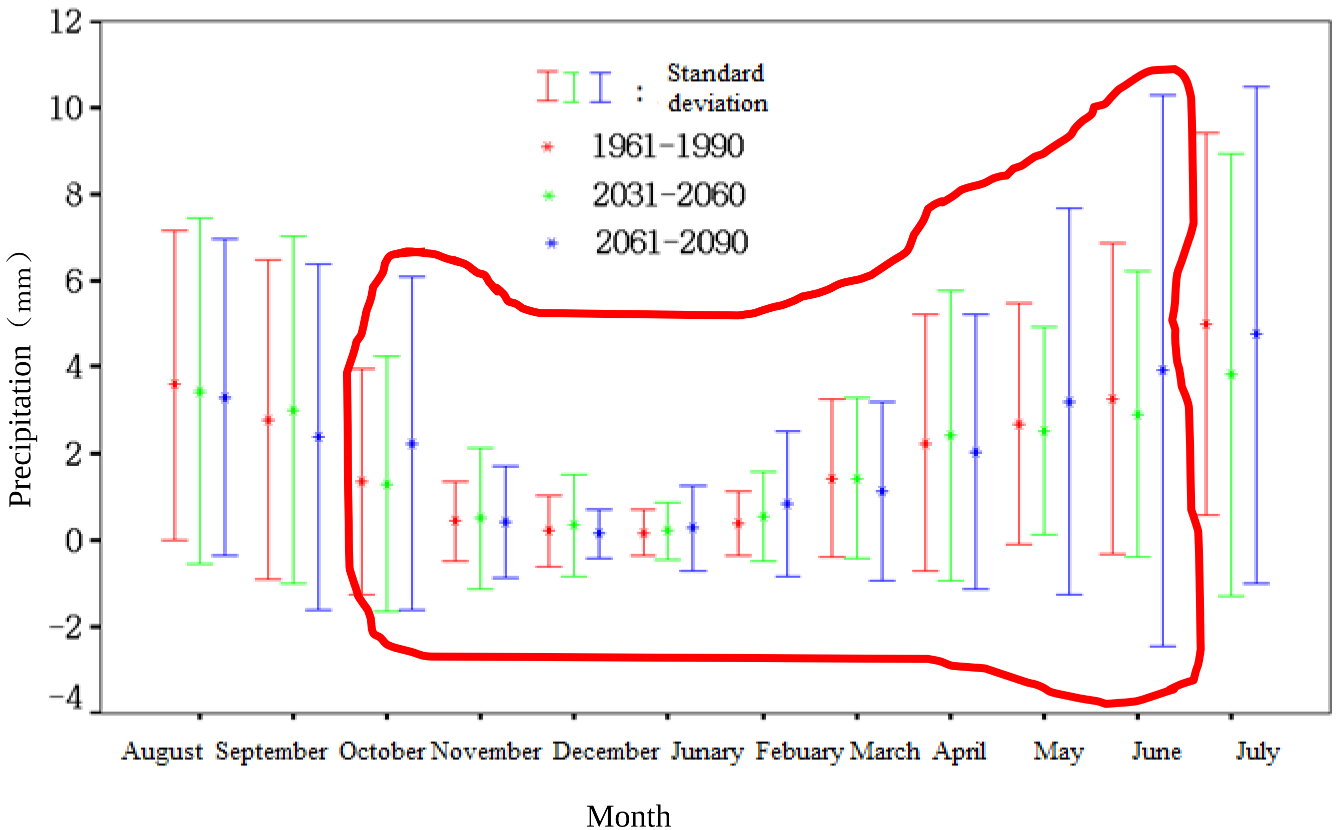
	1961-1990	2031-2060	2061-2090
Average precipitation#	1.89a（0.21*）	1.98a（0.21）	2.06a（0.23）

*：Brackets for the coefficient of variation;#:Different letters means significant at 0.05 level

Results and analysis

- **Change of climate resources(under A1B)**

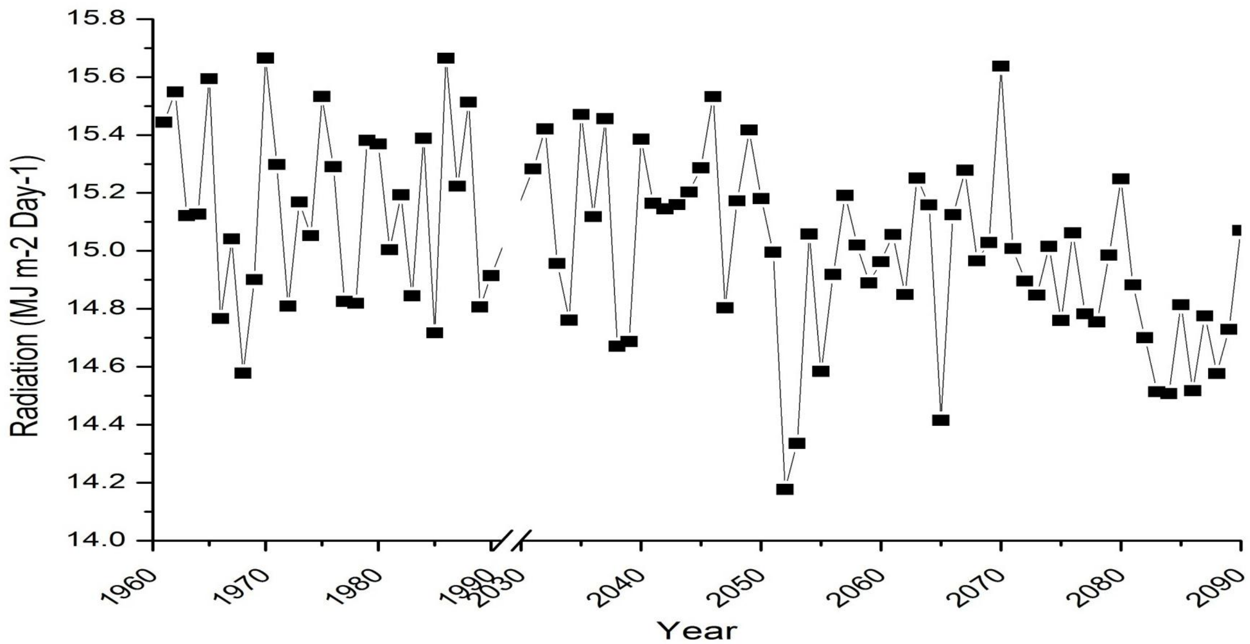
— Precipitation



Results and analysis

- **Change of climate resources(under A1B)**

— Radiation



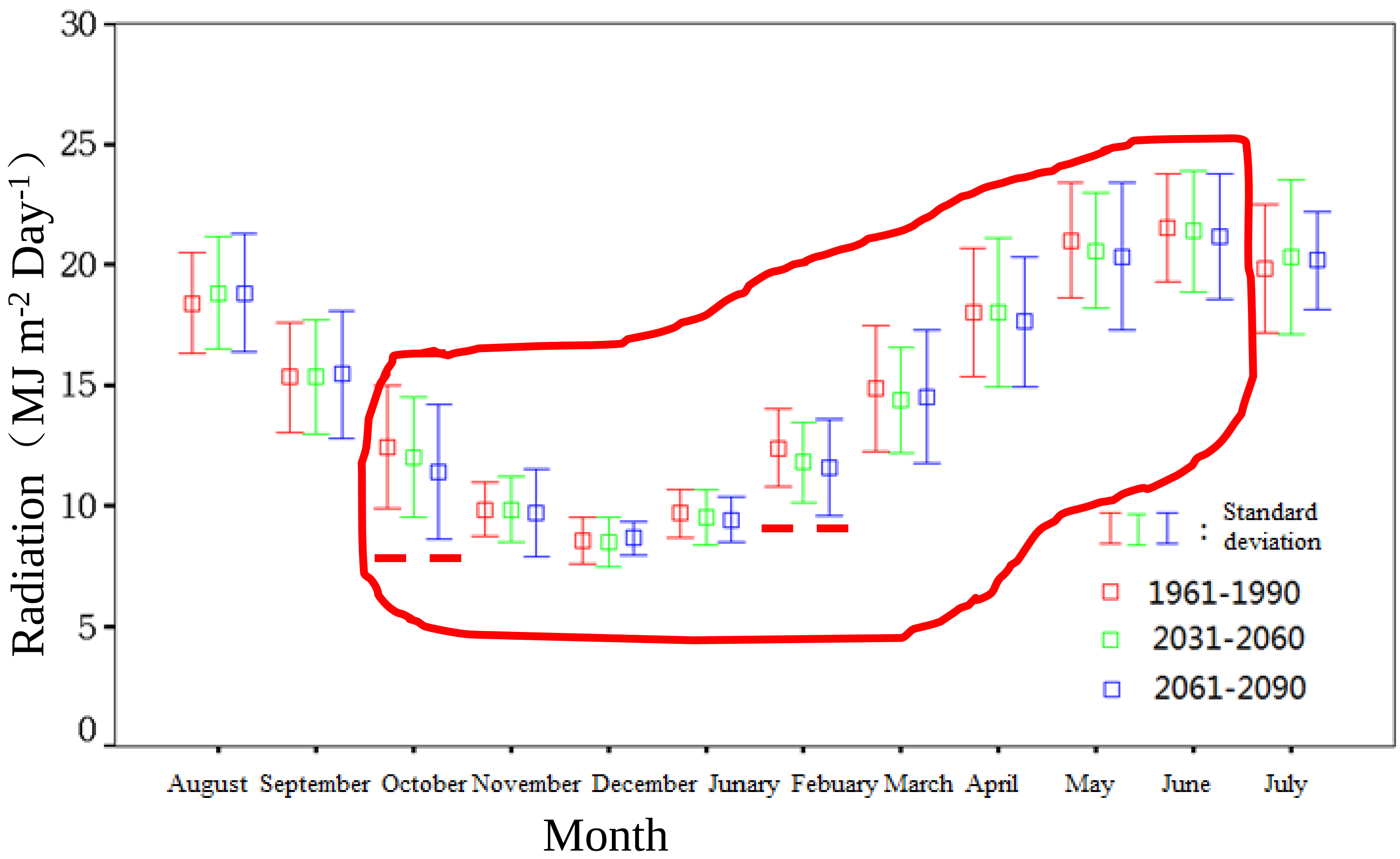
	1961-1990	2031-2060	2061-2090
Average radiation[#]	15.15[a]（0.02*）	15.05[ab]（0.02）	14.91[b]（0.02）

*： Brackets for the coefficient of variation;[#]:Different letters means significant at 0.05 level

Results and analysis

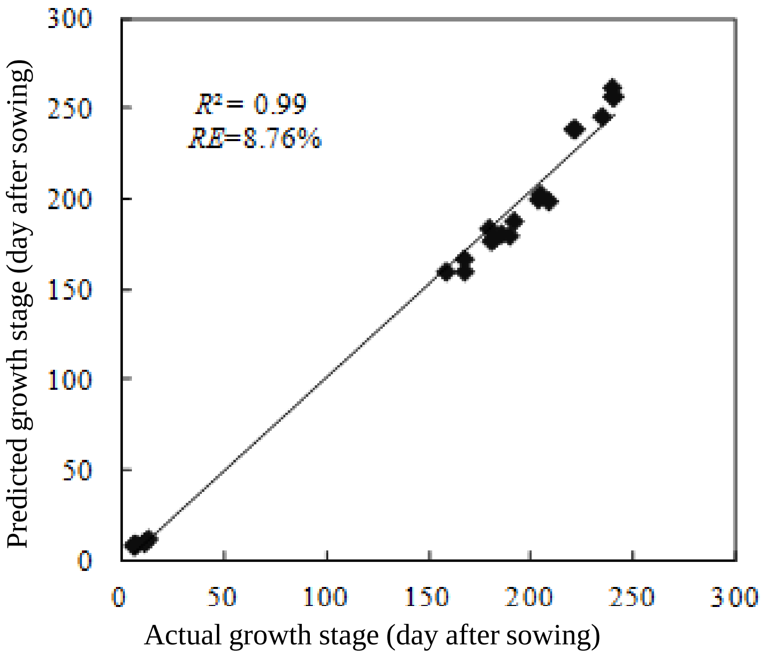
- **Change of climate resources(under A1B)**

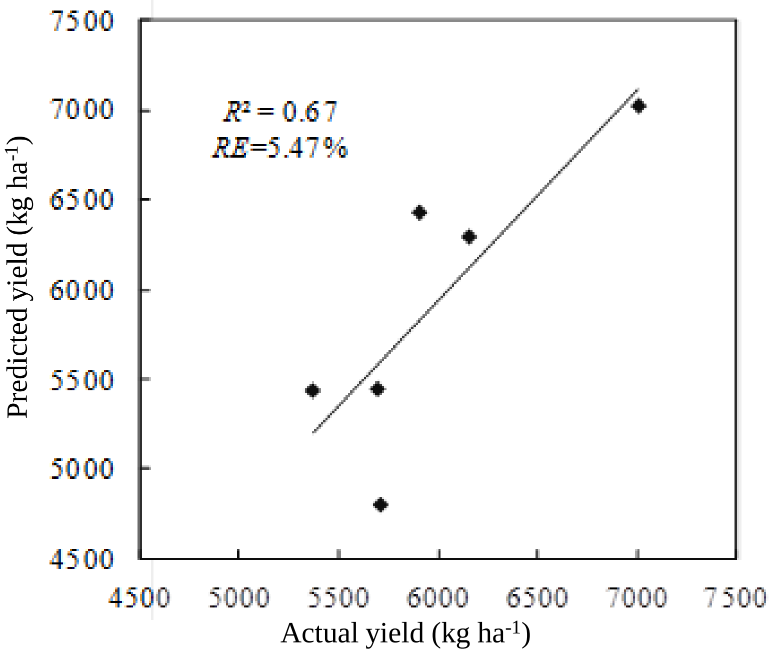
— Radiation



Results and analysis

2）Results of growth optimization





Comparison between predicted growth stage and actual growth stage, and between predicted yield and actual yield in years 2005 to 2010

Results and analysis

3）Effects of climate change on winter wheat production

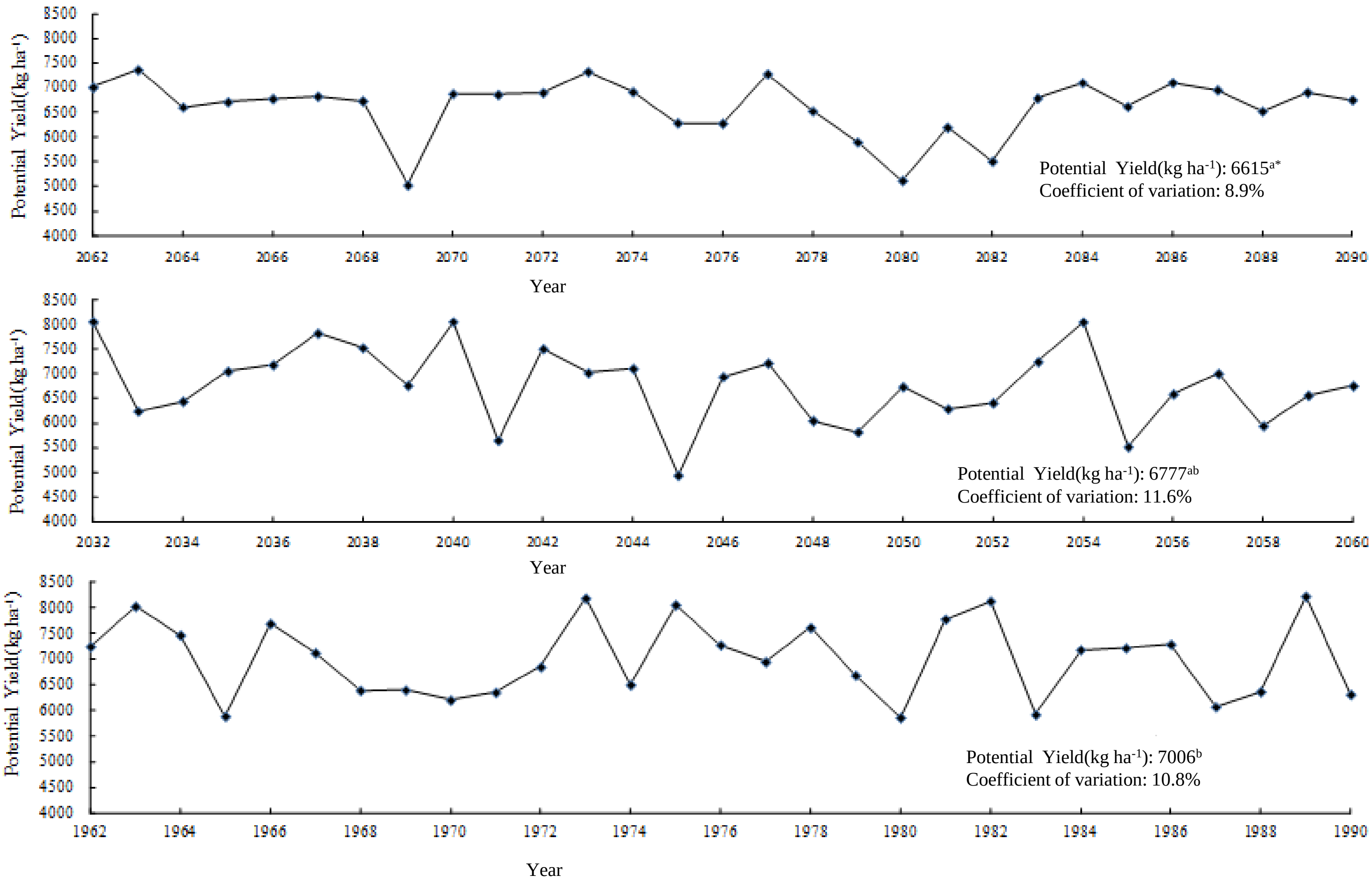
Table 1 Appeared time for different growth stage of winter wheat in BASELINE,2031-2060,2061-2090

Growth stage	BASELINE		2031-2060		2061-2090	
	Day after planting/day	Coefficient of variation/%	Day after planting/day	Coefficient of variation/%	Day after planting/day	Coefficient of variation/%
Emergence	11[a*]	10.82	9[b]	10.93	9[b]	9.18
Jointing	167[a]	3.23	151[b]	4.05	141[c]	5.10
Flagging	201[a]	2.22	186[b]	2.61	176[c]	3.49
Flowering	214[a]	2.02	199[b]	2.68	190[c]	3.10
Mature	246[a]	1.72	231[b]	2.02	222[c]	2.64

Note: * In row, different letters means significant at 0.05 level

Results and analysis

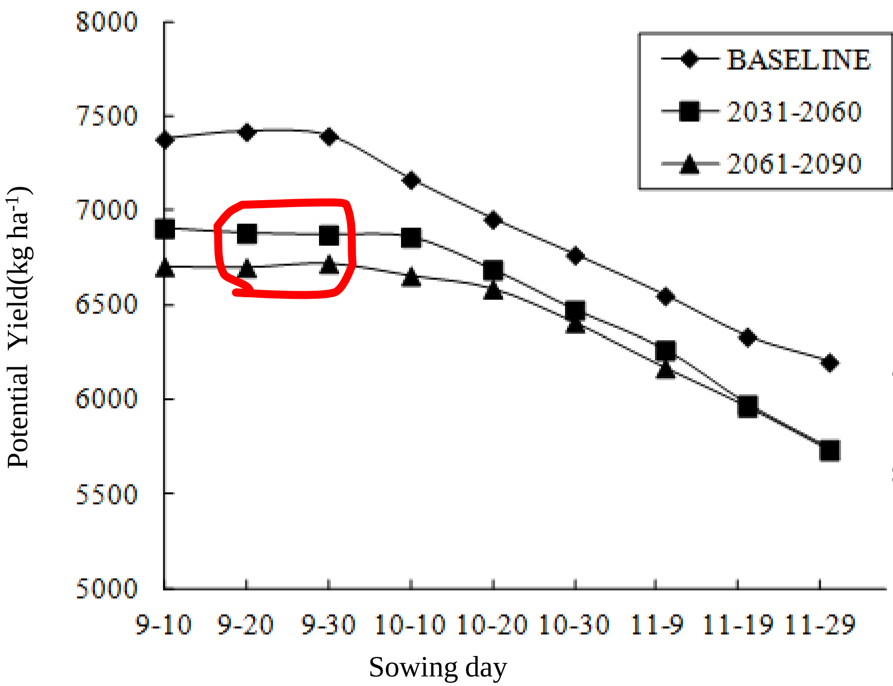
3）Effects of climate change on winter wheat production

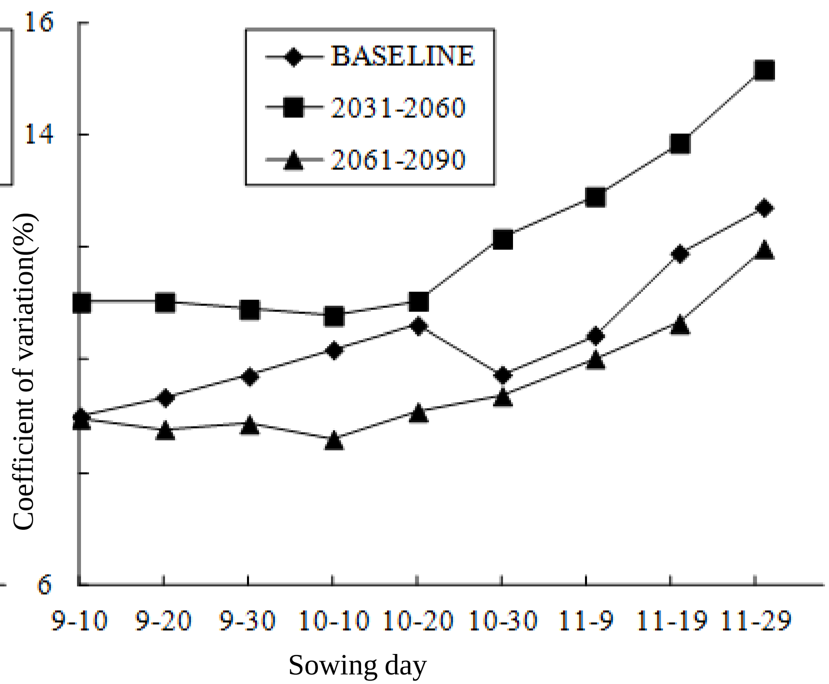


Model simulated winter wheat yield in different period(*different letters in yield means significant at 0.05 level)

Results and analysis

4) Adaptation strategies for winter wheat field management





Effects of sowing data on winter wheat yield

4. Results and analysis

4) Adaptation strategies for winter wheat field management

Table 2 The best irrigation schedule for different sowing day in BASELINE,2031-2060 and 2061-2090

Sowing day	Periods	Winter water	Jointing water	Heading-Flowering water	Yield
Sep. 20th	2031-2060	180 mm	150 mm	100 mm	6900
	2061-2090	180 mm	150 mm	100 mm	6756
Sep. 30th	2031-2060	120 mm	150 mm	100 mm	6890
	2061-2090	120 mm	150 mm	100 mm	6733
Oct. 15th	BASELINE	60mm	100 mm	100mm	7144

The situation now:

Sowing day： Between Oct. 7^{th} to Oct. 20^{th}

Winter water： 120mm； Jointing water： 150mm； Heading-Flowering water： 150mm

Yield： 7006 kg ha^{-1}

5. Conclusion

– After optimization, CERES- Wheat model can predict winter wheat growth accurately.

– Compared to BASELINE, Heat increases significantly, and radiation decreases, and precipitation does not change significantly in years 2031 to 2060 and years 2061 to 2090 under A1B greenhouse gas emission scenario.

– Change of climate resource will results decline of winter wheat yield in north west of Shandong plain. That may caused by incompletely vernalization of wheat with increased temperature in winter. Thus, Breading winter wheat cultivar, that have reduced dependence of vernalization, will be the target of the local breeding

– Under the condition of local cultivar has not much improved, it is best to advance broadcast day before 2 or 3 weeks, and keep local irrigation system with increasing winter water amount, in order to maximize production and reduce inter-annual variation.

Summary

- These research are based on State Key Basic Research Program and Environment Protection Public Welfare Project of China. It is keep on going now.
  - GHG's distribution is focused in our research is not only just on quantity, but also its spatial distribution. These data can be retrieved automatically with high time sequence.
  - More elements, such as land cover types, temperature, precipitation, Sensible heat, Latent heat, ET, NPP, GPP, etc are considered for ecological effects.
  - Not only scenarios analysis, some feasible adaption measurement are researched in small region.

Hope to cooperate in the near future, ……

Thanks!

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