Assessment on Potential Impacts of Global Climate Change on Runoff, Soil Erosion and Crop Yields on the Loess Plateau of China

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Nov. 6, Yangling, Shaanxi, China

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1. Background

- **Climate change could cause potential impacts on hydrology process, soil erosion and crop yields, which would influence food and ecological safety in the world.**
- **The Loess Plateau is located in the temperate zone with semi-arid and arid climate, climate changes could cause great impacts on hydrology process, soil erosion, and crop yields.**
- **However, there is little information on assessing the potential impacts of climate change on runoff, soil erosion, and crop yields.**

1. Background

- The impacts of climate changes need to be assessed on the Loess Plateau.
- Current evaluated methods: Integration of agricultural or hydrological models with future climate scenarios, GCM is the main source of climate scenarios.
- When GCMs are used, two major limits exist in the site-specific impacts assessment (i.e., spatial and temporal scale mismatches).

Mismatches between GCM and agro-ecological models

Spatial and temporal scale of GCM

Spatial scale：Grid

---Different grids in various GCMs

GFDL-R15 (7.5° × 4.4°)--USA

CCSR/NIES (5.625° × 5.625°)--Japan

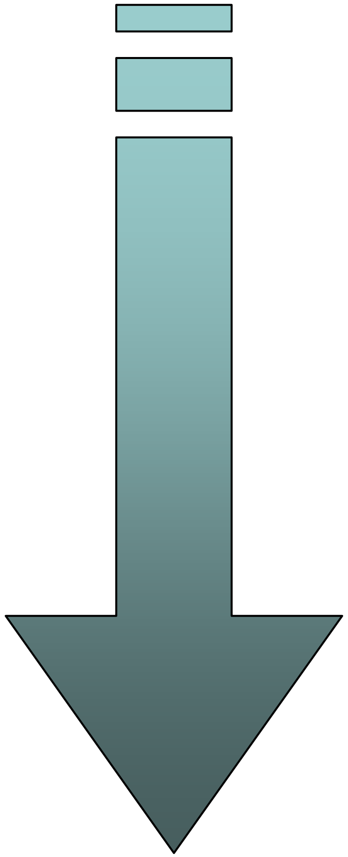
CSIRO-Mk2b (5.625° × 3.25°)--Australia

CGCM1 & 2 (3.75° × 3.75°)-Canada

HadCM2 & 3 (3.75° × 2.5°)--UK

GFDL-R30 (3.75° × 2.24°)--USA

ECHAM4 & NCAR-PCM (2.8125° × 2.8125)--USA



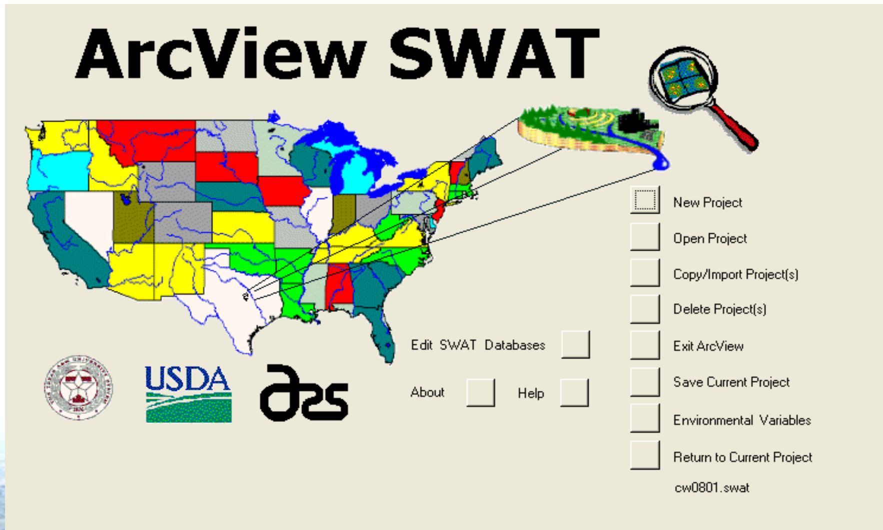
Increasing resolution

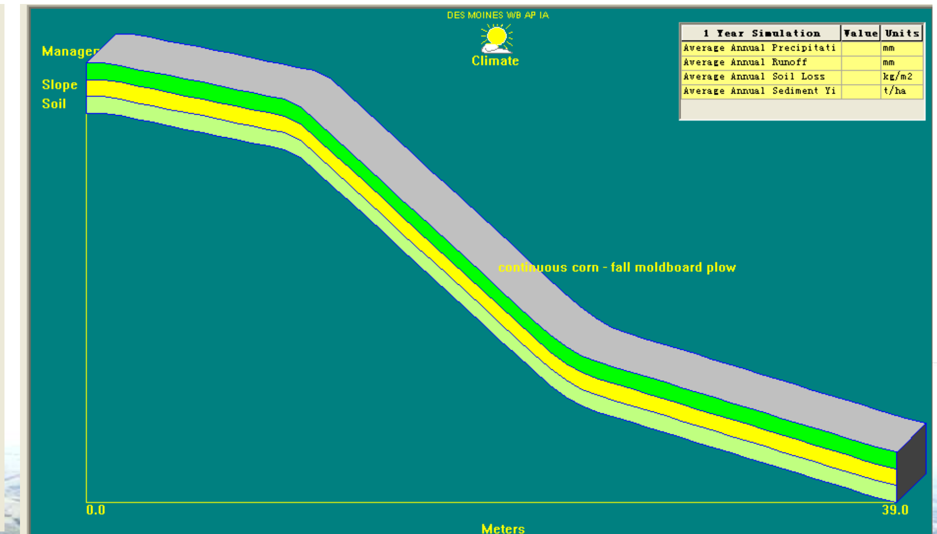
Model resolution increases, but it does not match needs of agro-ecological model

Temporal scale：Monthly data for most models

Model Input requirements

- **Temporal:** **Agricultural and hydrological models such as SWAT and WEPP require daily weather data**
- **Spatial:** **The site-specific weather data should be used**





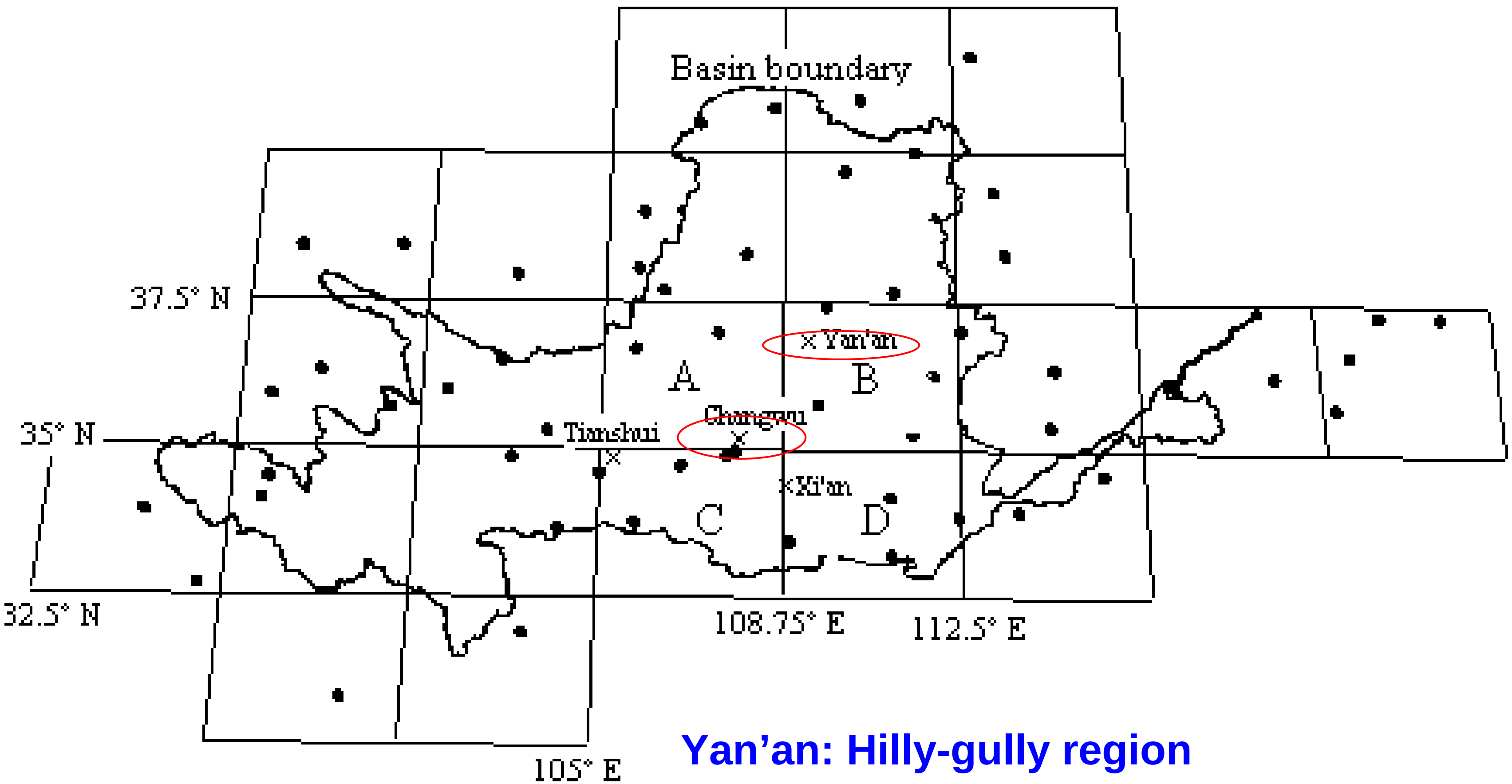
2. Objectives

- **Spatially downscale** GCM grid output with a statistical approach to target station;
- **Temporally downscale** GCM monthly output to daily series data;
- **Assess** the potential impacts of HadCM3 (UK) -projected climate changes during 2010-2049 under A2, B2, and GGa on runoff, soil erosion and crop yields on the Loess Plateau.

A2: care more economy, not care environment (high emission scenarios)
B2: care more environment (low emission scenarios)
GGa: emission rate according to 1860-1990 (current)

3. Methodology

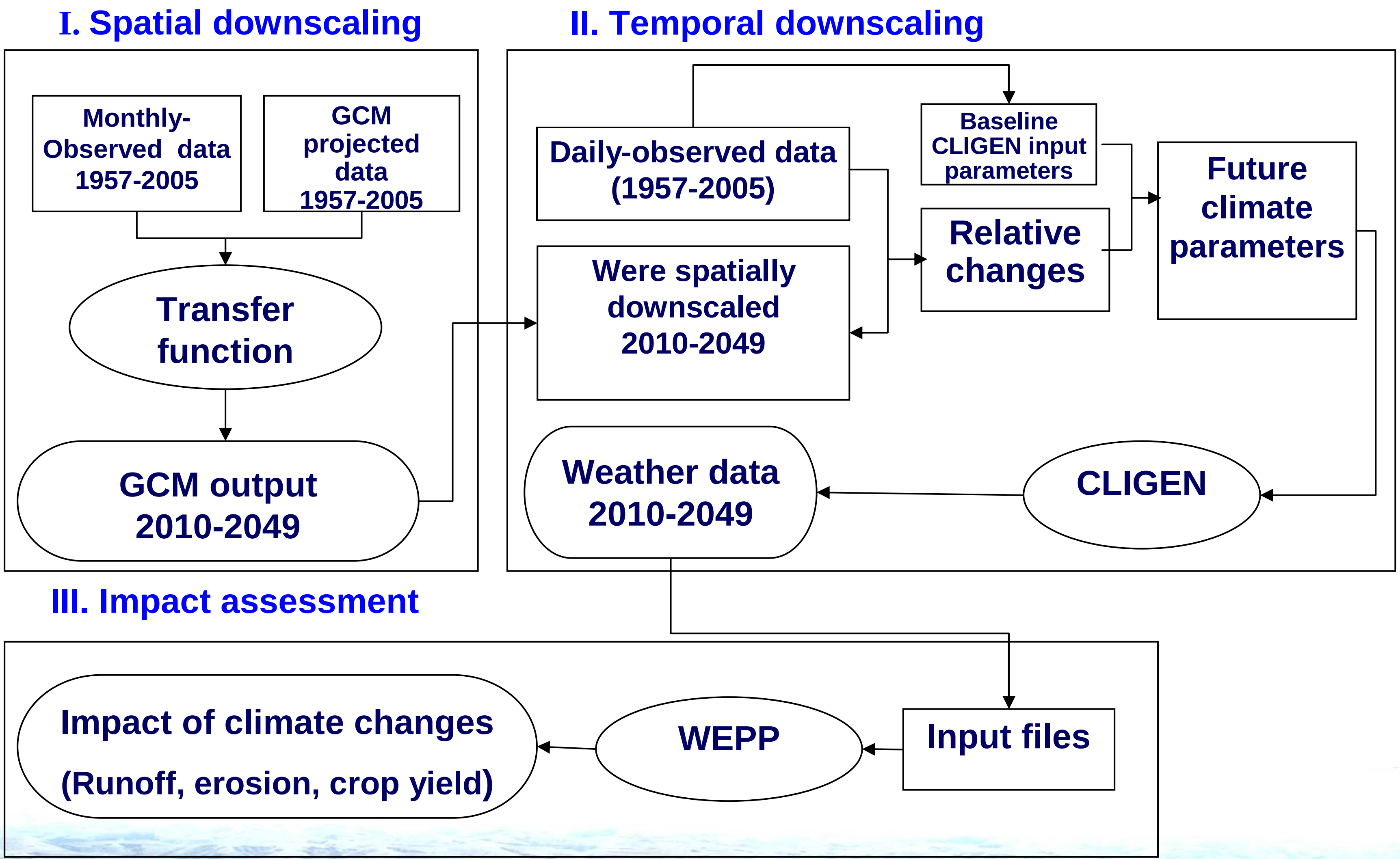
Research sites



Yan’an: Hilly-gully region

Chengwu: Tableland with gullies region

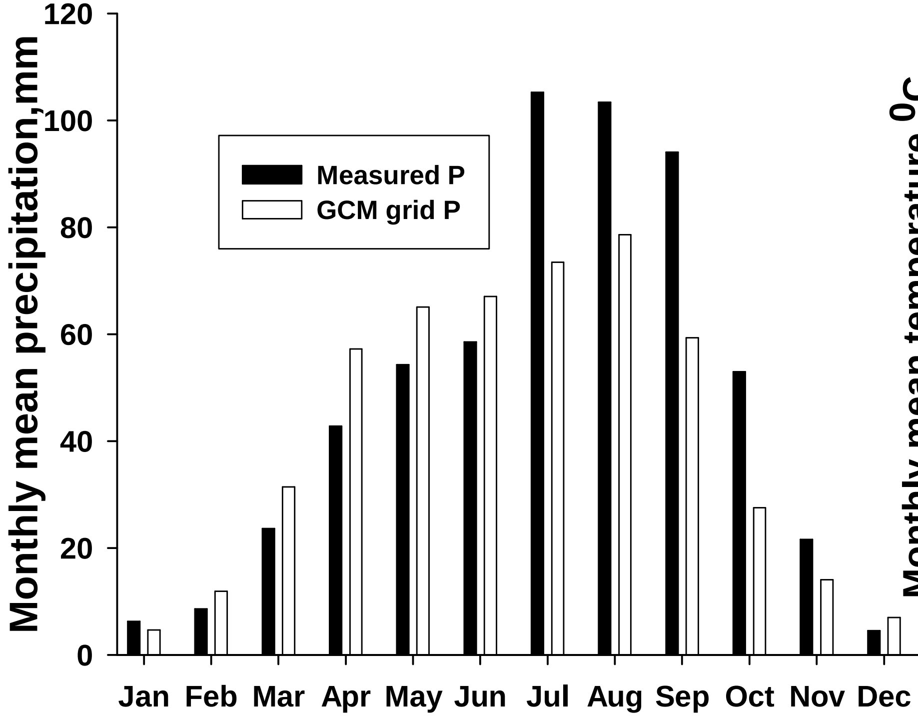
3. Methods

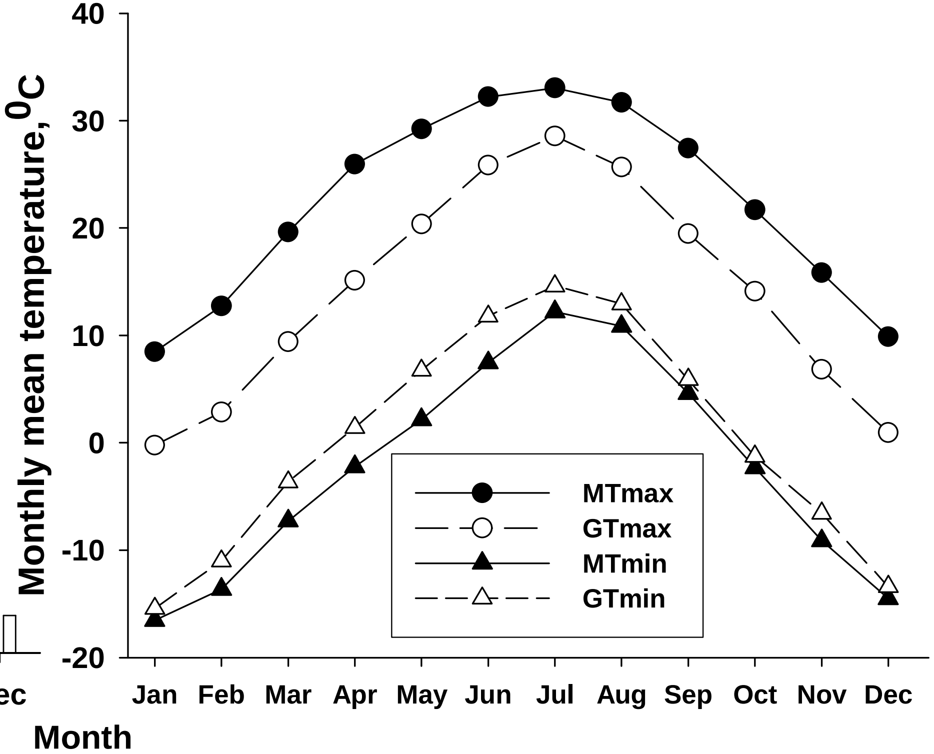


Relative change: P variance rations, mean T shifts, T variance rations

4. Results

Spatially Downscaling

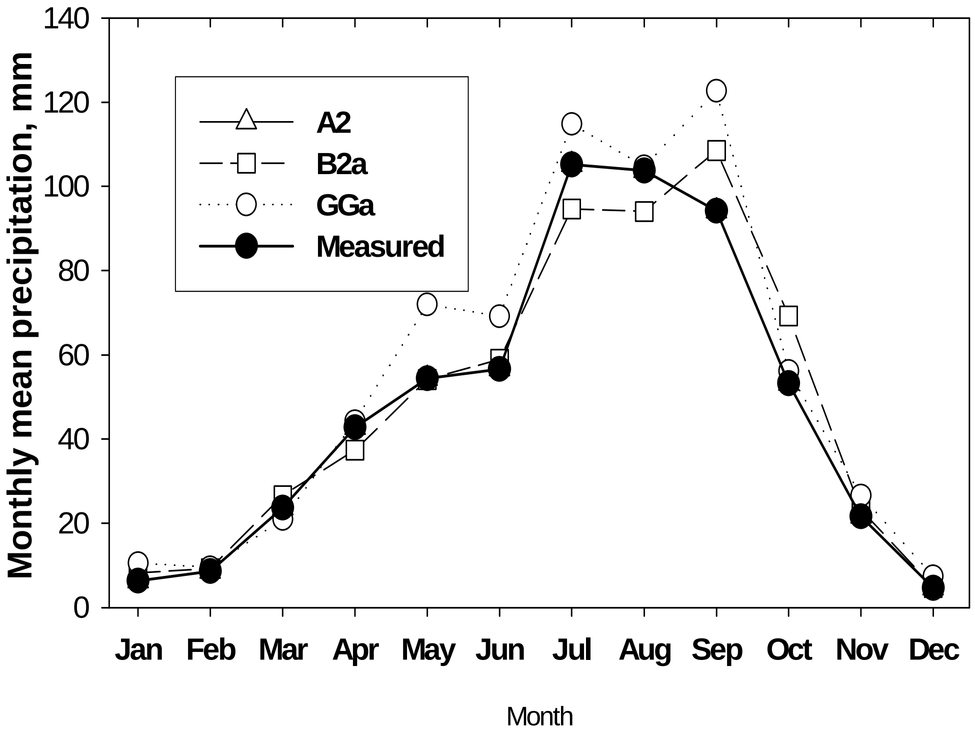




- ✓**1957~2005: Annual precipitation of measured data and A2 are 576.3 and 497.6 mm, respectively, relative error = -13.7%**
- ✓**The Tmax of hindcasts are underestimated (-8.2℃)**
- ✓**The Tmin of hindcasts are overpredicted (2.5℃)**

4. Results

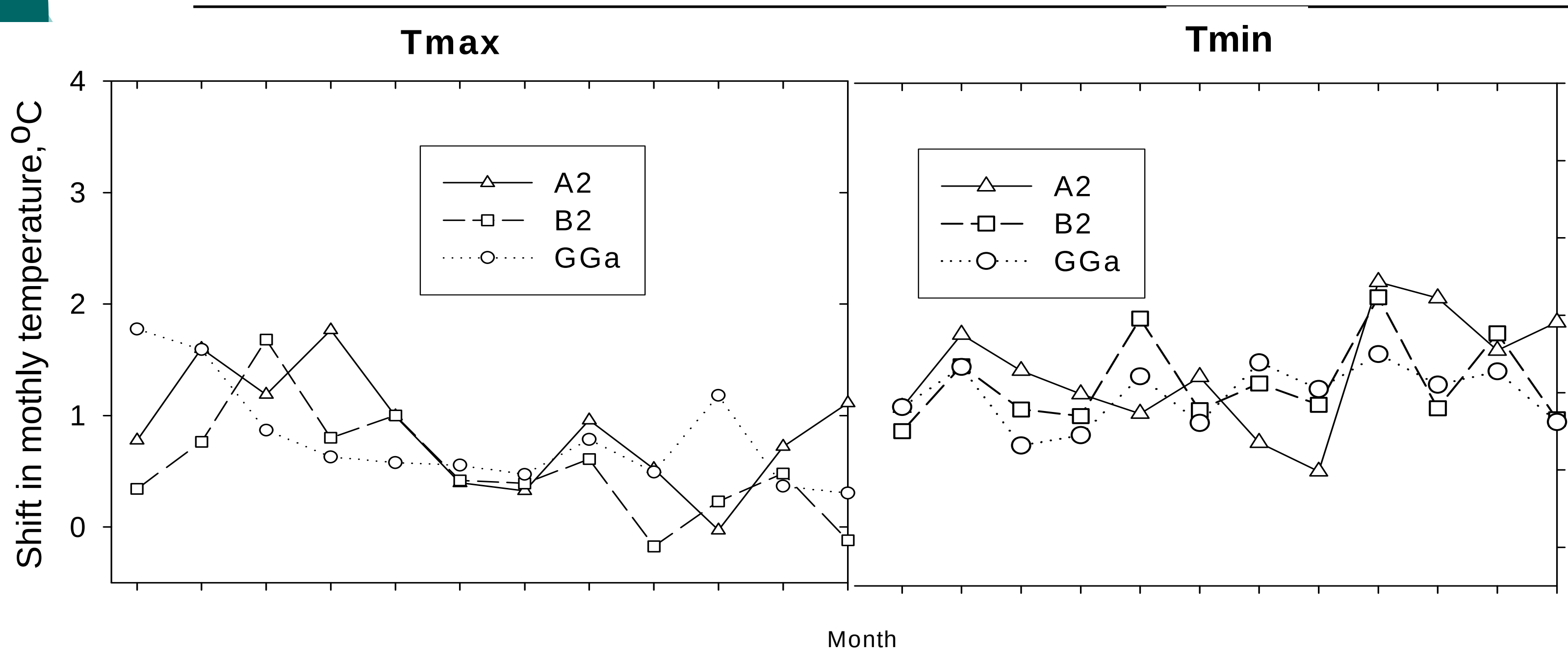
Predicted Climate Change--Precipitation



- ✓ Predicted mean annual precipitation under A2, B2 and GGa increases by 10.8, 80.6, and 101.4 mm, respectively (they increases by 1.8%,13.9%, and 17.5%).
- ✓ They greatly increases in May and in July to September.

4. Results

Predicted Climate Change -Temperature



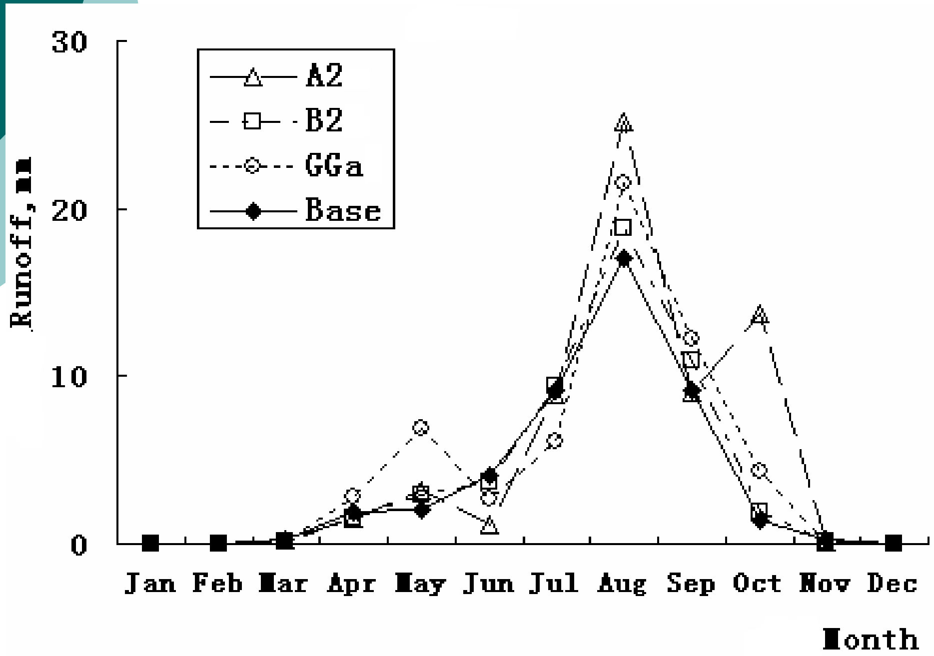
✓Tmax increases by 0.9, 0.5, and 0.8 ℃; Tmin increases by 2.3, 2.1, and 2.0 ℃, respectively, under A2, B2 and GGa scenarios.

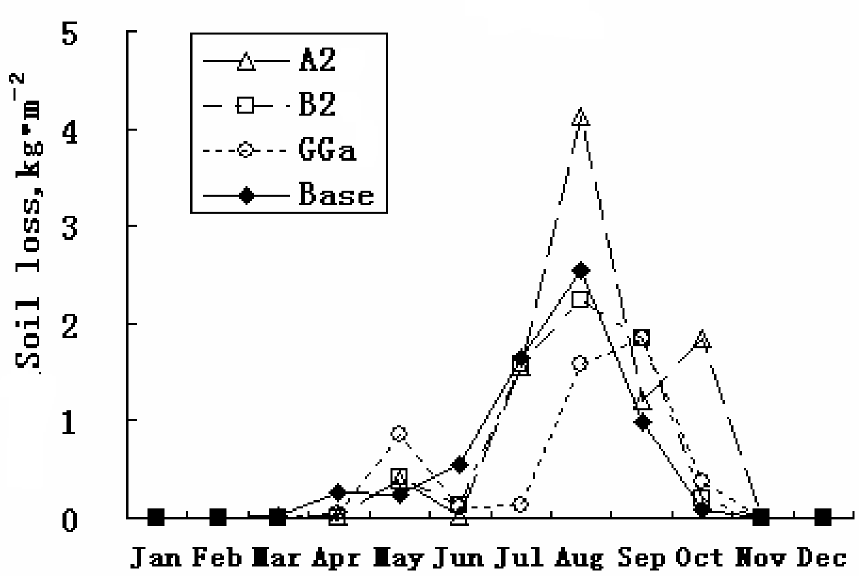
✓The increases of Tmin are higher than that of Tmax.

✓Two peaks of temperature increase: Spring and Winter, which would mean warmer winter in 2010-2049.

4. Results

Monthly change of runoff and soil loss under conventional tillage





✓**Runoff and soil loss increase in May, especially in August to October**

Annual change of runoff, soil loss, and crop yield under conventional tillage

Scenario（CO_2）		Base (350)		A2 (592)		B2 (416)		GGal (445)	
Slope		5°	10°	5°	10°	5°	10°	5°	10°
Runoff	**Depth/mm**	43	51	**93**	**104**	**79**	**89**	**69**	**77**
	Change/%	0	0	**117**	**104**	**83**	**74**	**60**	**51**
Soil loss	**Rate/t·ha^{-1}**	3.1	9.3	**8.4**	**21.6**	**6.1**	**16.7**	**4.7**	**12.2**
	Change/%	0	0	**171**	**133**	**98**	**79**	**51**	**31**
Wheat	**Yield/t·ha^{-1}**	2.9	2.8	2.9	2.8	3.5	3.4	4.1	3.9
	Change/%	0	0	**0**	**0**	**21**	**21**	**41**	**39**
Maize	**Yield/t·ha^{-1}**	7.0	6.8	8.0	7.8	8.6	8.3	9.6	9.5
	Change/%	0	0	**14**	**15**	**23**	**22**	**37**	**40**

✓Predicted runoff and soil loss under A2 is the most increase, under GGa is the least, and under B2 is intermediate.

✓Predicted crop yield under GGa is the most increase; under A2 is not change for wheat and the least increase for maize; and under B2 is intermediate.

Annual change of runoff, soil loss, and crop yield under conservation tillage

Scenario (CO_2)		Base (350)		A2 (592)		B2 (416)		GGal (445)	
Slope		5°	10°	5°	10°	5°	10°	5°	10°
Runoff	Depth/mm	43	51	55	62	44	50	35	41
	Change/%	0	0	27	21	3	-2	-18	-19
Soil loss	Rate/ t·ha^{-1}	3.1	9.3	1.7	5.5	1.5	4.7	1.8	5.7
	Change/%	0	0	-45	-41	-51	-50	-41	-39
Wheat	Yield/t·ha^{-1}	2.9	2.8	3	2.9	3.7	3.6	4.1	4
	Change/%	0	0	5	5	28	29	41	42
Maize	Yield/t·ha^{-1}	7	6.8	8.1	7.9	8.1	8	8.7	8.6
	Change/%	0	0	16	16	16	17	25	26

- ✓Predicted runoff under A2 is the most increase, under GGa is the most decrease, and under B2 is not change.
- ✓Predicted soil loss decreases under A2, B2, and GGa scenarios, there is no differences among three scenarios.
- ✓Predicted crop yield increase under A2, B2, and GGa scenarios; under GGa is the more increase.
- ✓Conservation tillage greatly decreases soil loss and increases crop yield, compared with conventional tillage.

5. Conclusions

- **Climate: Compared with the current climate, at three emission scenarios (A2, B2 and GGa) of HadCM3, precipitation could change from 2.9% to 37%; maximum temperature and minimum temperature might rise 0.6 from 1.6 ℃ and 1.1 to 1.7 ℃, respectively, during 2010 to 2049.**
- **Impacts: Under conventional tillage, WEPP would predict -26% to 115% change for runoff, -31% to 126% change for soil loss, 3% to 17% change for wheat yields, and 7% to 24% change for maize yields during 2010-2049.**
- **Countermeasures: Under conservation tillage, soil loss would decrease by 39% to 51% and crop yield greatly increases, compared with conventional tillage. .**

5. Conclusions

- Due to the uncertainty of climate change, impacts of climate change with GCM are not quantitatively reliable but qualitative reliable to some extent。
- When spatial/temporal transformations are carried out, proper methods should be selected.
- Conservation tillage can reduce the adverse impacts of climate change significantly and have great potential for application.

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