Projection of Rice Yield in 21st century in South Korea under RCP8.5 Scenario using a Mechanistic Crop Model

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1. INTRODUCTION

It is clear that climate change can affect crop productivity because agriculture is highly sensitive to climate. Assessment of climate change impacts on crop production is priority to obtain the adaptation strategies for climate change. Mechanistic or process–oriented crop models have been used to estimate crop production in future climate condition. There was an attempt of the impact assessment in Korea using Oryza2000 under A1B scenario (Lee et al. 2012). In this study, rice yield changes in South Korea were estimated using Oryza2000 under RCP 8.5 scenario. In addition, It was also to compare the original model with modified Oryza2000.

2. MATERIALS AND METHODS

Crop model: Oryza2000 was used to simulate rice yield in future. In this study, we used not only original Orza2000 but also modified Orzya2000. Grain filling (not published) and heat sterility module (Nguyen et al. 2014) is improved in modified Oryza2000. Partitioning coefficient approach is adopted to calculate yield in Oryza200O meanwhile grain filling approach is adopted in modified Oryza2000 (Fig. 1).

Calculating yield based on partitioning coefficient in Oryza2000	Calculating yield based on grain filling ratio in Modified Oryza2000

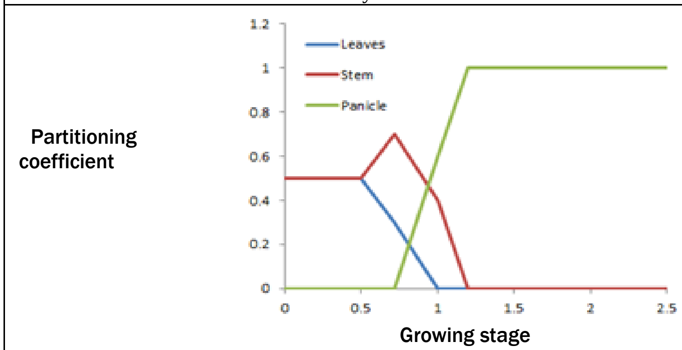	IF(DVS.GE.1) THEN
	EGNO1 = NSPM2*(26.0 - GWSUM1)/NOTNUL(26.0 - 9.0) !No. of unfilled spikelet
	FGNO1 = NSPM2 - EGNO1 ! No. of filled spikelet
	RIPENR1 = FGNO1/NOTNUL(NSPM2)*100 !grain filling ratio
	TEMPWRR2 = 26.0*NGRM2*RIPENR1/10000 ! yield es
	END IF

Fig. 1. Yield calculation method difference between Oryza2000 and Modified Oryza2000.

Scenario: RCP 8.5 scenario, provided by the Korea Meteorological Administration (KMA), was grid data with 12.5km resolution (http://ccs.climate.go.kr/personal_RCP/korea_step1.php).

Weather data of 55 stations were extracted to make weather input file of Oryza2000 from these grid data (Fig. 2). The 55 stations have been used to forecast rice yield annually in South Korea (Lee et al. 2015). Simulations of three ecotypes (early, middle and middle-late maturity) were carried out at every station from 1985 to 2100 with current optimal seeding date, standard nitrogen application and full irrigation. All management control and genetic coefficient were same as Lee et al. (2011).

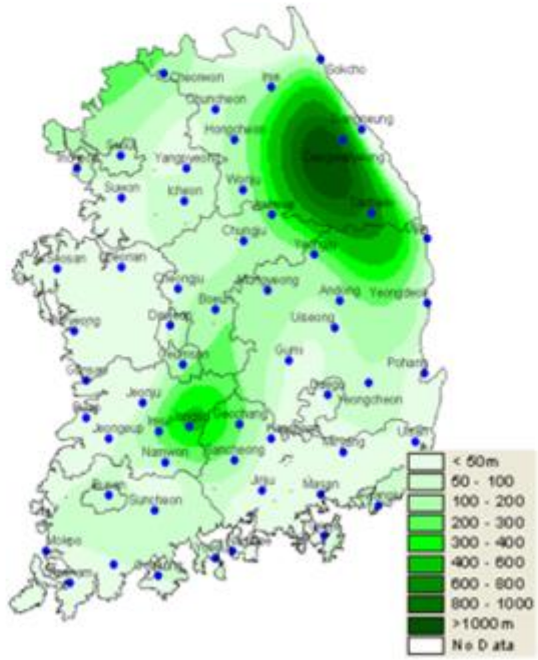

Fig 2. Location of 55 weather stations in South Korea

3. RESULTS

Simulation results of original Oryza2000 showed that the average yield of 55 stations in early and middle maturity type increased up until mid-2040s and subsequently slowly decreased. Comparing to early and middle maturity type, the yield of middle-late maturity type changed dramatically with same pattern of others (Table 1). Dramatic change of middle-late maturity type reflected expansion of arable area for middle-late maturity type. It was caused by that rice could be cultivated and harvested at high land area (Fig 4).

Table 1. Relative yield of 55 stations in Oryza2000 and Modified Oryza2000 with a base year of 1986-2005.

Year	Early		Middle		Middle-late	
	Oryza2000	Modified Oryza2000	Oryza2000	Modified Oryza2000	Oryza2000	Modified Oryza2000
1986-2005	100	100	100	100	100	100
2006-2025	108	109	111	110	111	112
2026-2045	115	114	114	112	121	121
2046-2065	115	112	115	111	123	122
2066-2085	113	105	114	105	121	117
2086-2100	111	93	114	94	118	105

Meanwhile different results were obtained in modified Oryza2000. Relative yields of all types showed same pattern as original Oryza2000 until mid-2040s. However, yields of all ecotypes sharply dropped after mid-2040s. Relative yields of original model were higher than of modified model after mid-2040s. This trend was particularly noticeable in the middle-late maturity (Table 1).

In time series, rice yield was estimated to be increased until mid-2040s in both models. These results suggest that current seedling date could be effective for near future. However relative yield of modified model is expected to decrease in the second half of the 21st century. Its results from that modified model is more sensitive to high temperature during grain filling period. If we accept result of modified one, seedling date will be re-determined in the future. In terms of spatial variation, the yield variation of middle-late maturing type was larger than others (Figs. 2, 3 and 4). The productivity of middle and middle-late in the north plain and eastern highland particularly changed with the passage of time. Harvesting of middle and middle-late in present is impossible because of low temperature. Due to climate change, the cultivate area of these two types will be expanded. It can be one option for adaptation.

Overall, two models showed similar prediction in relative yield before mid-2040s. After mid-204s, original model simulated rice yield higher than modified even though there was one difference between two models in grain filling process. These results showed that yield could be changed by a small difference. Therefore, crop models will be improved for accurate prediction.

ACKNOWLEDGEMENTS

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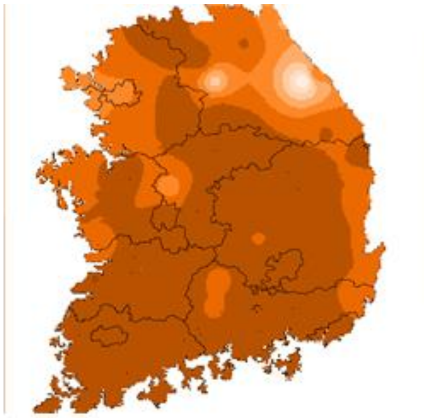
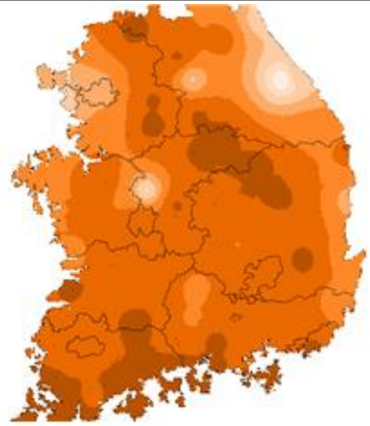
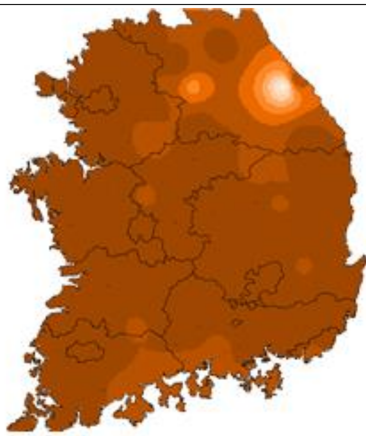
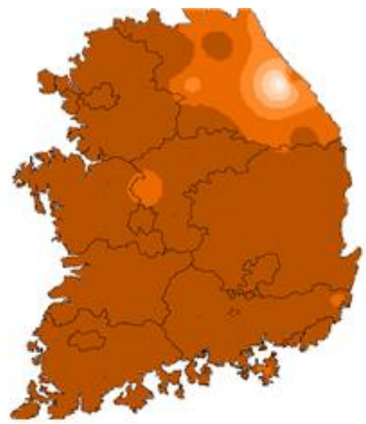
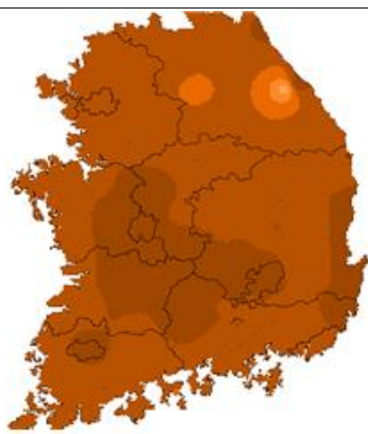
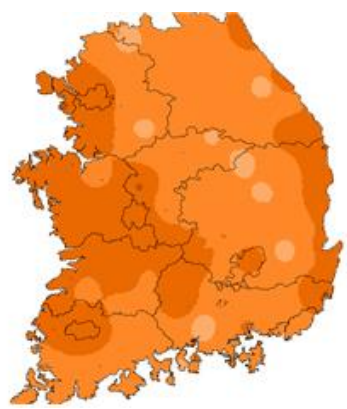
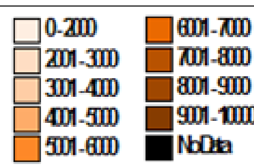
Lee, C., J. Kim, J. Shon, H. Yang, Y. Yoon, K. Choi and K. Kim. 2012 Impacts of climate change on rice production and adaptation method in Korea as evaluated by simulation Ssudy. *Korean Journal of Agricultural and Forest Meteorology* 14:207-221.

Oryza2000	Modified Oryza2000
	
1986-2005	1986-2005
	
2026-2045	2046-2065
	
2086-2100	2086-2100
Fig. 2. Projected yields change of early maturing type in South Korea	 (kg/ha)

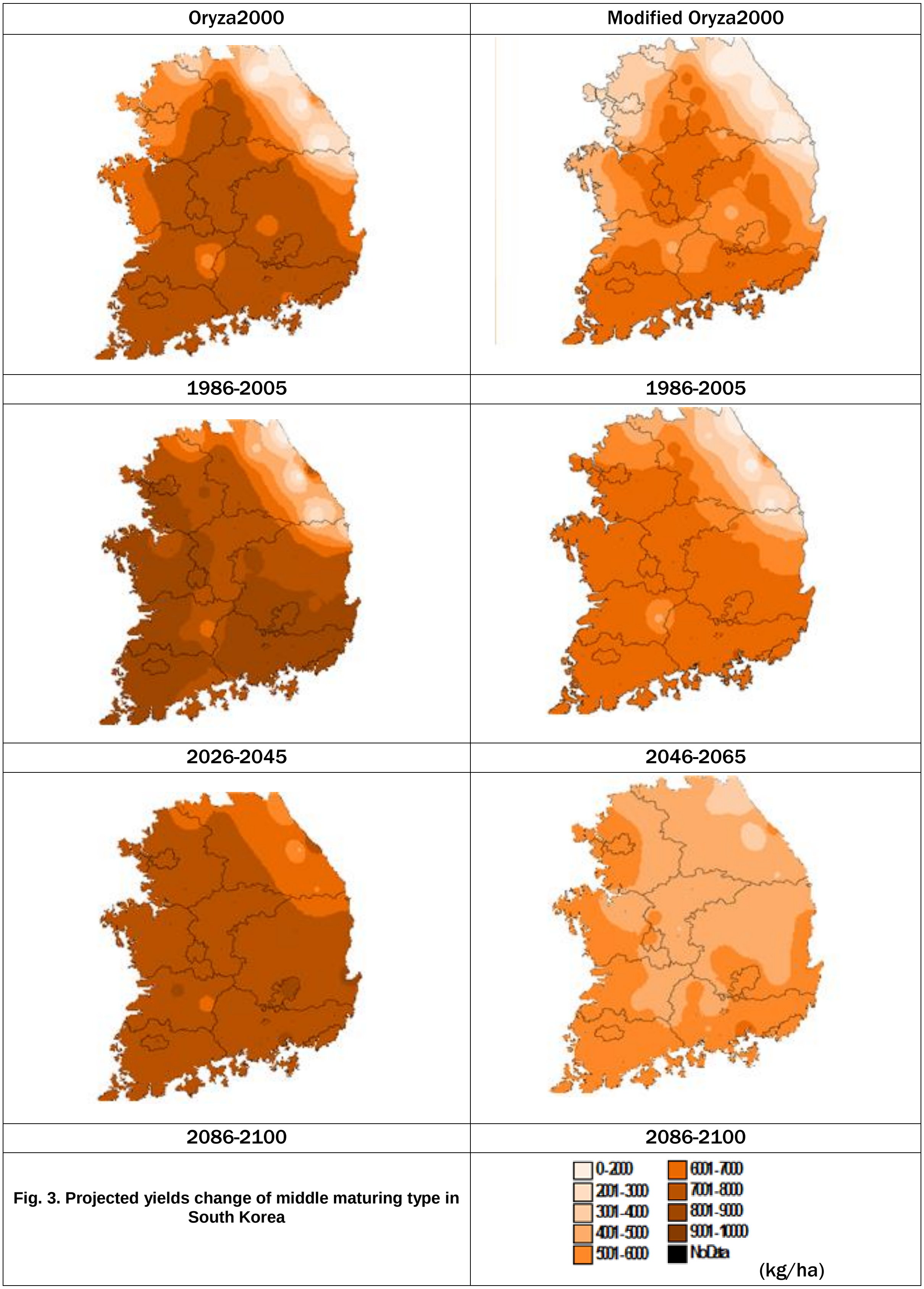
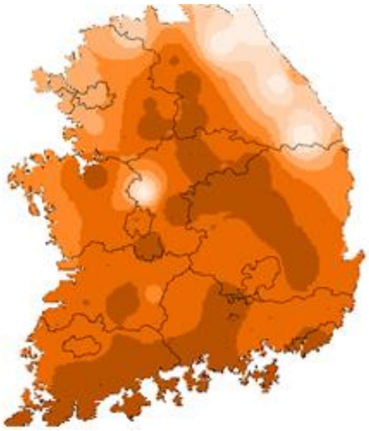
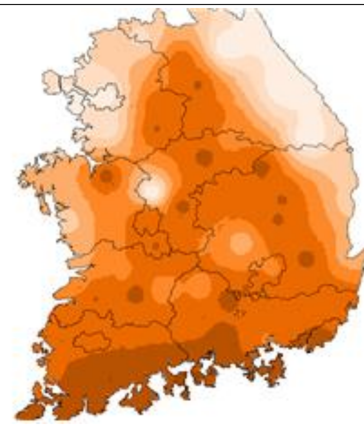
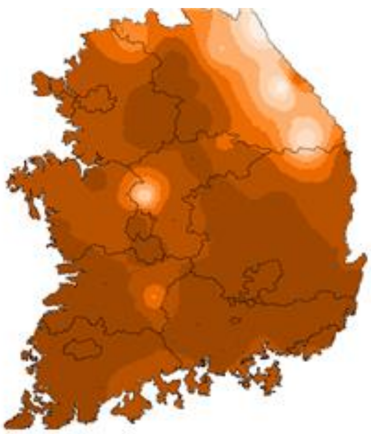
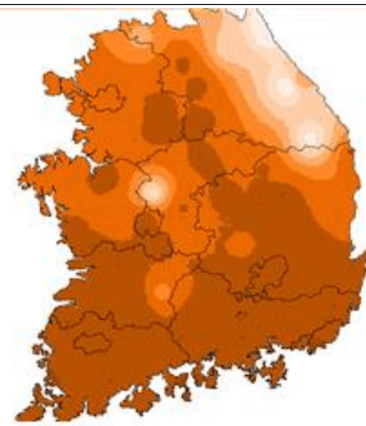
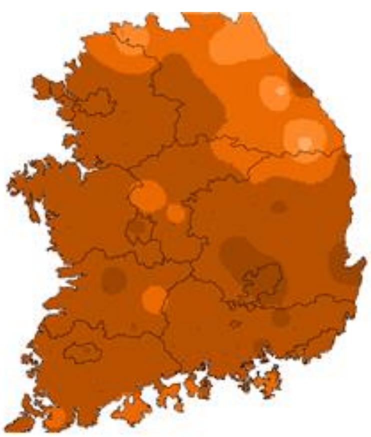
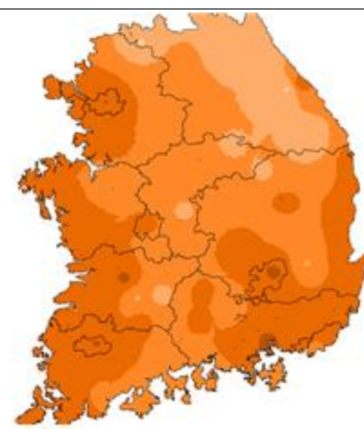
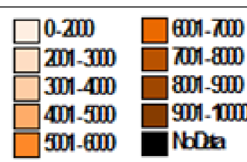


Fig. 3. Projected yields change of middle maturing type in South Korea

Oryza2000	Modified Oryza2000
	
1986-2005	1986-2005
	
2026-2045	2046-2065
	
2086-2100	2086-2100
Fig. 4. Projected yields change of middle -late maturing type in South Korea	 (kg/ha)