How Does Future Climate Affect Planting Dates of Rain-Fed Paddies in Northeast Thailand?

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Background

Key food producer Thailand faces climate issues

- Thailand has over10 million ha of paddy.
- 60% are located in Northeast(NE) but most are rain-fed, so production fluctuates every year.
- Rice production estimation is important for policy makers.

Fig.1 Regions in Thailand

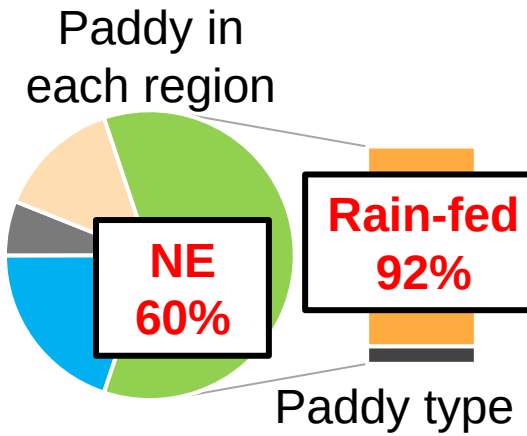
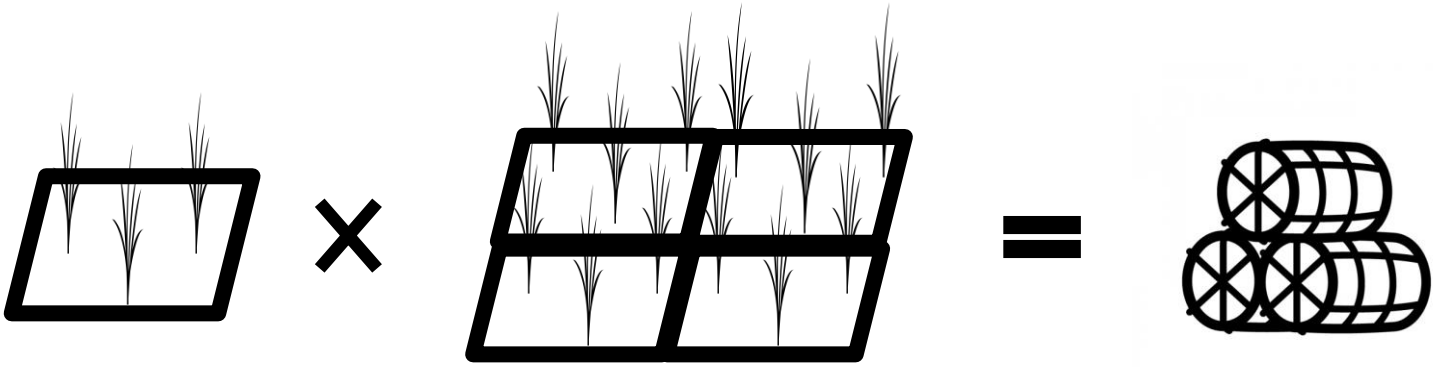


Fig.2 Paddy location and types

Literature Review

Many research estimated unit yield of rice paddy



Horie (1993); Masutomi (2008); Tanaka et. al. (2011); Babel (2011) estimated unit yield of rice paddy

Literature Review

Growth period depends on Planted date

- Harvest date is almost fixed on early Dec.
- Unit yield depends on growth period.

Planting date estimation is important for yield estimation

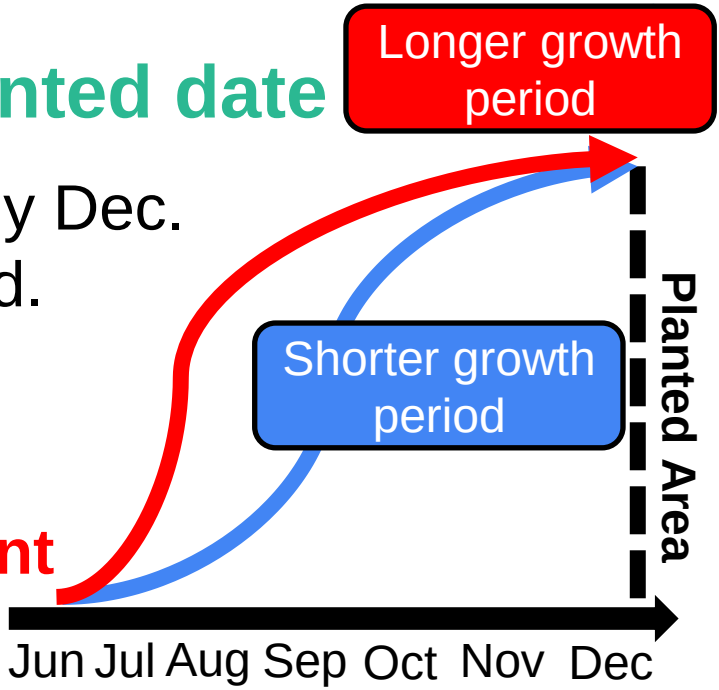


Fig.3 Relation between planting date and growth period

Objective

For a better yield estimation…

- To develop **a planted area estimation model**
- To assess **a variability of planting date and area under future climate** with a developed model

Materials and methodology

Table.1 Data used for this study

Data	Spatial resolution	Temporal resolution	Source
Observed Rainfall	10km	Daily	TMD
Temperature	0.5˚	Monthly	CRU TS 4.06
Paddy Location	1km	-	LDD
Elevation	1km	-	USGS
Planting area	-	3 times / month	Sawano et. al.(2008)

Note: TMD refers Thai Meteolorogical Department, CRU refers Climate Research Unit, LDD refers Land Development Department, USGS refers U.S. Geologocal Survey,

Materials and methodology

Planting date is estimated by One-dimensional vertical water balance model

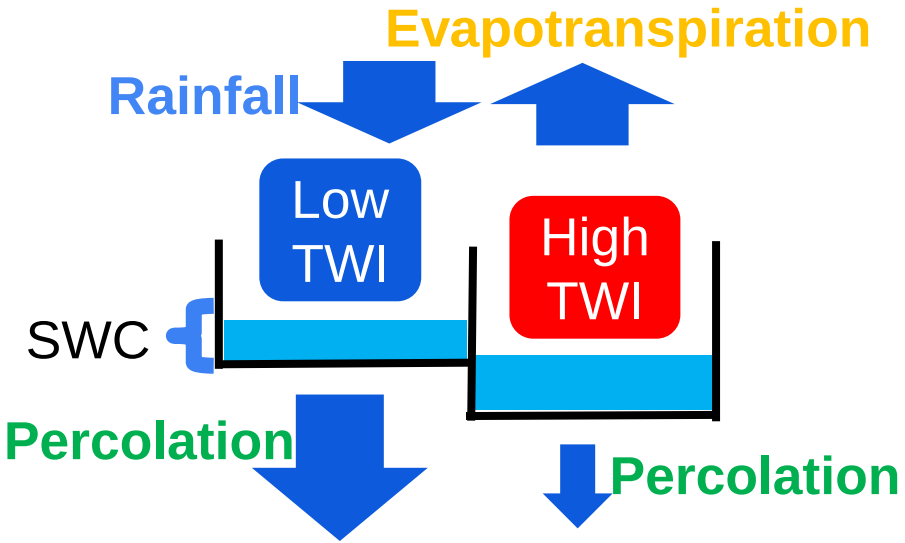


Fig.4 Schematic image of the model

$$SWC_{t-\frac{1}{2}} = SWC_{t-1} + R_t - ETP_t$$

$$SWC_t = SWC_{t-\frac{1}{2}} - P_t$$

$$P_t = \max\left(0, SWC_{t-\frac{1}{2}} - WR\right) * kP$$

$$kP = a/TWI$$

Where, SWC: soil water content, R: rainfall, ETP: evapotranspiration, P: percolation, t: day step, WR: water retention, kp, percolation coefficient, **TWI: topographic wetness index**

Materials and methodology

TWI is an index of the relative depth of groundwater, calculated from elevation data.

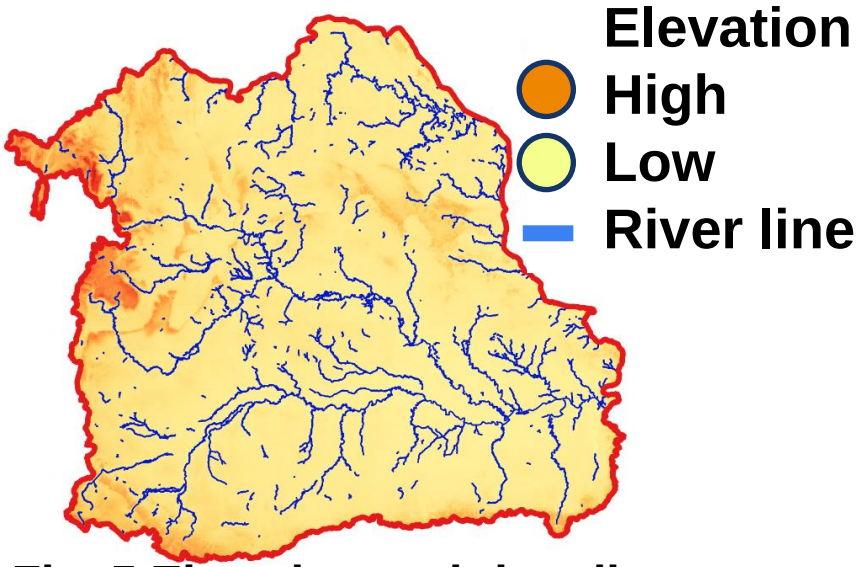


Fig. 5 Elevation and river line

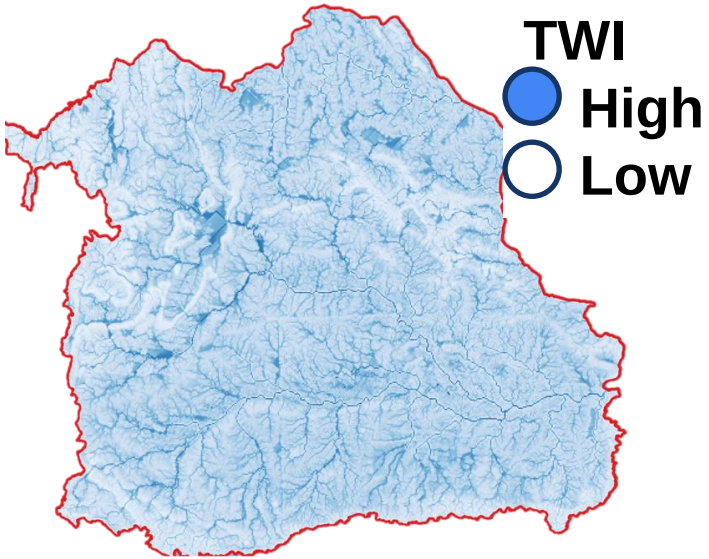


Fig. 6 Spatial distribution of TWI

Materials and methodology

Rainfall Data from Global Climate Model(GCM)

- Rainfall data from GCM in 2006-2100, under RCP8.5 scenario are used

Table.2 Future rainfall data used for this study

Data Source	Spatial resolution	Temporal resolution	Source
MIROC5	1.4° × 1.4°	Daiily	AORI, 2015
GISS-E2-H	2.0° × 2.5°	Daiily	NASA/GISS, 2014
IPSL-CM5A-MR	1.3° × 2.5°	Daiily	Foujols et. al., 2016

Note: RCP refers Representative Concentration Pathway, AORI refers Atomosphere and Ocean Institute, the University of Tokyo, NASA/GISS refers NASA Goddard Institute for Space Studies

Materials and methodology

Estimated Rainfall Data

- Future rainfall data in 2006-2100, under RCP8.5 scenario are used.
- Direct bias correction(Watanabe, 2020) with observed data.

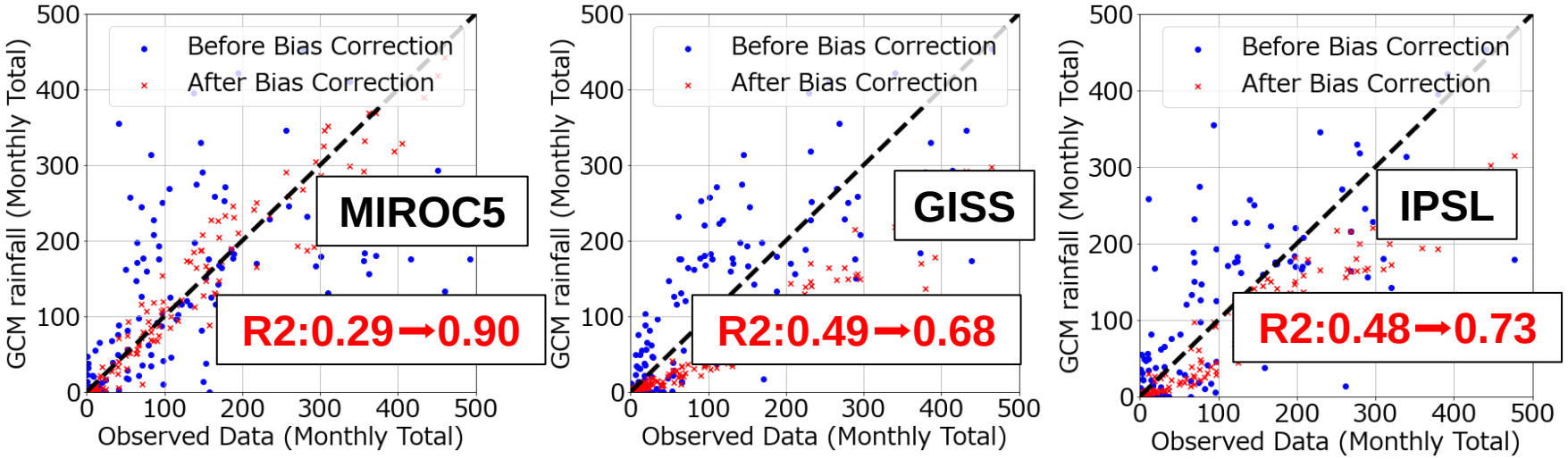


Fig.7 Before vs After bias corrected data

Result

Estimated planting date and area are almost reproduced the observed values.

- Good accuracy in a dry year(2005) with 8.7% error.
- In a wet year(2004), the error is larger with 13.9%.

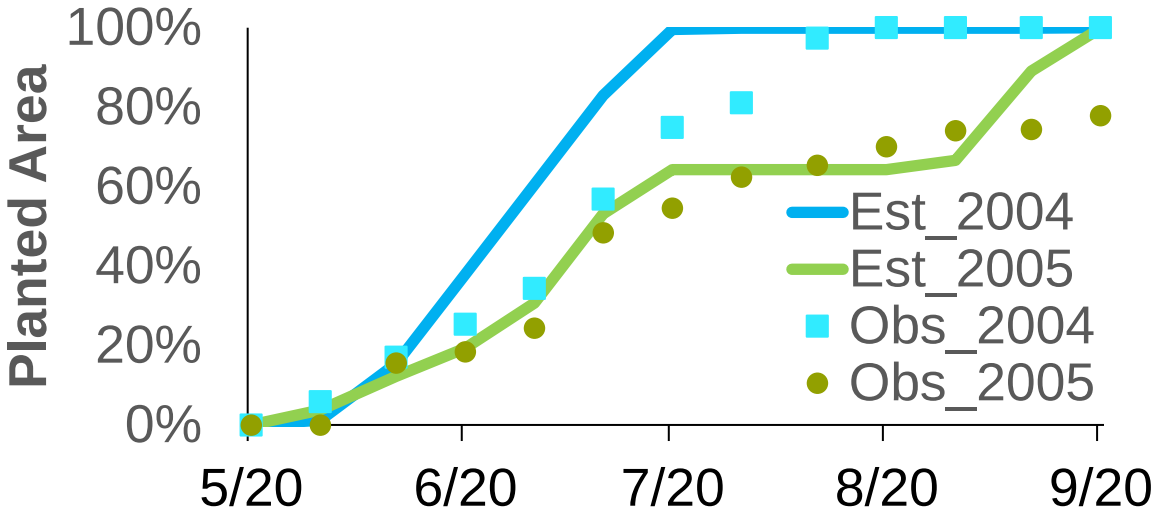


Fig.8 Estimated and Observed planted area

Result

Planting dates are getting later in present.

- Planting area increase in Jun has declined, while those in Aug and Sep has increased.
- Planting date has shifted by 1-2 month.

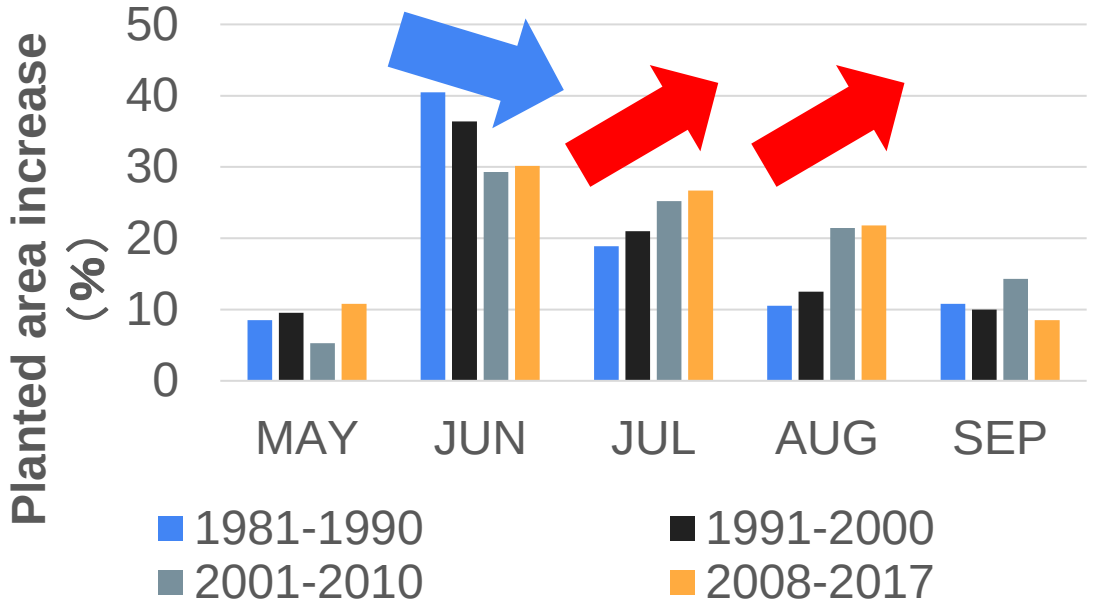


Fig.9 Monthly planted area increase in 4 periods

Result

Delayed trend of planting is expected to continue by 2050s.

- Planting date will be delayed until 2050s, moved forward from 2060s.
- The trend of planting delay is expected to continue until 2050s and stop in a distant future.

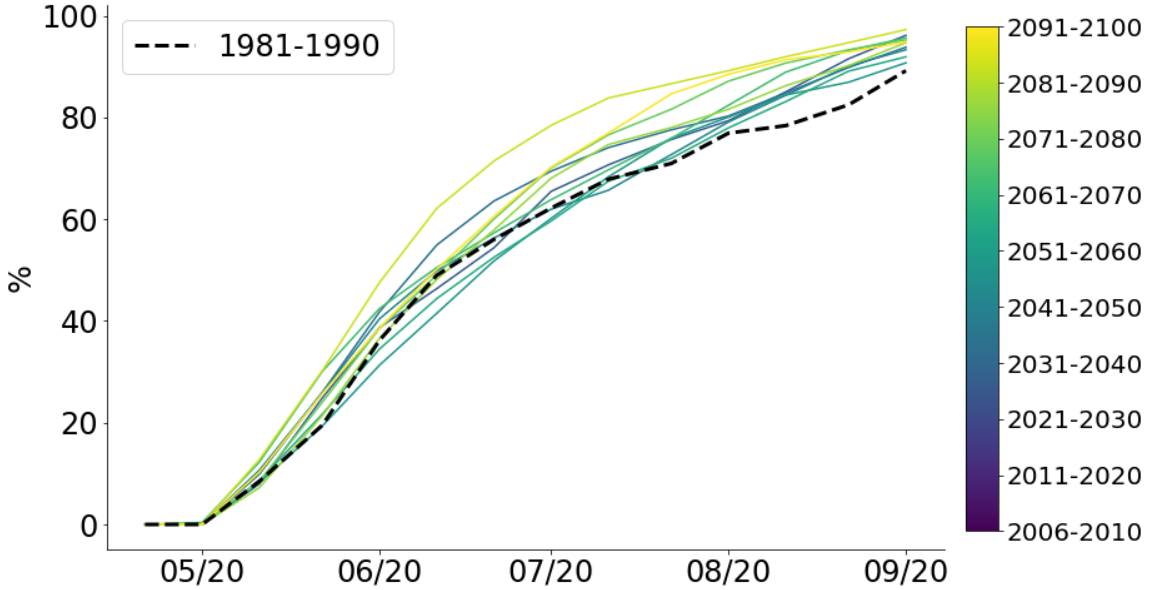


Fig.10 Ensembled estimation of planted area

Conclusion

- Planting date varied more and was delayed from 1980s to 2010s, showing climate change impact has been apparent already.
- The delay in planting dates seen in present is expected to continue by the near future of 2050s, but shift earlier after 2050s.
- In years with significant planting delays, the economic feasibility of timely supplemental water use through groundwater or pump irrigation increases.

Limitation and future work

- Limited validation data requires preparing longer-term, broader validation data using satellite imagery analysis.

- The proposed model does not consider the change of planting method from transplanting to direct seeding.

- Future studies should consider increased evapotranspiration using projected temperature data.

Reference

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- Horie, 1993, Predicting the Effects of Climatic Variation and Elevated CO2 on Rice Yield in Japan, Journal of Agricultural Meteorology, 5, 567-574.
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- Shinji Sawano et al., 2008, Modeling the dependence of the crop calendar for rain-fed rice on precipitation in Northeast Thailand, Paddy Water Environment, 6, 83-90.
- Sukanya Sujariya et al., 2019, Rainfall variability and its effects on growing period and grain yield for rainfed lowland rice under transplanting system in Northeast Thailand, Plant Production Science, 1-12.

Appendix

- GCM used for this study express lower rainfall in near future, more in distant future

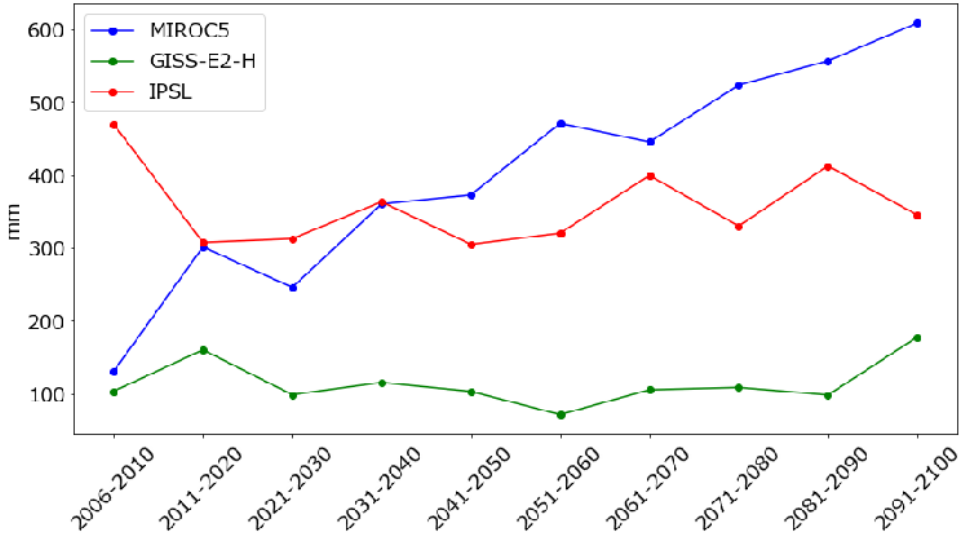


Fig.10 Averaged rainfall from Jun to Aug under future climate

Appendix

Planting dates vary more in recent.

- In 2008-, variation of planting date is larger than in 1981-.
- Determining planting date is getting harder.

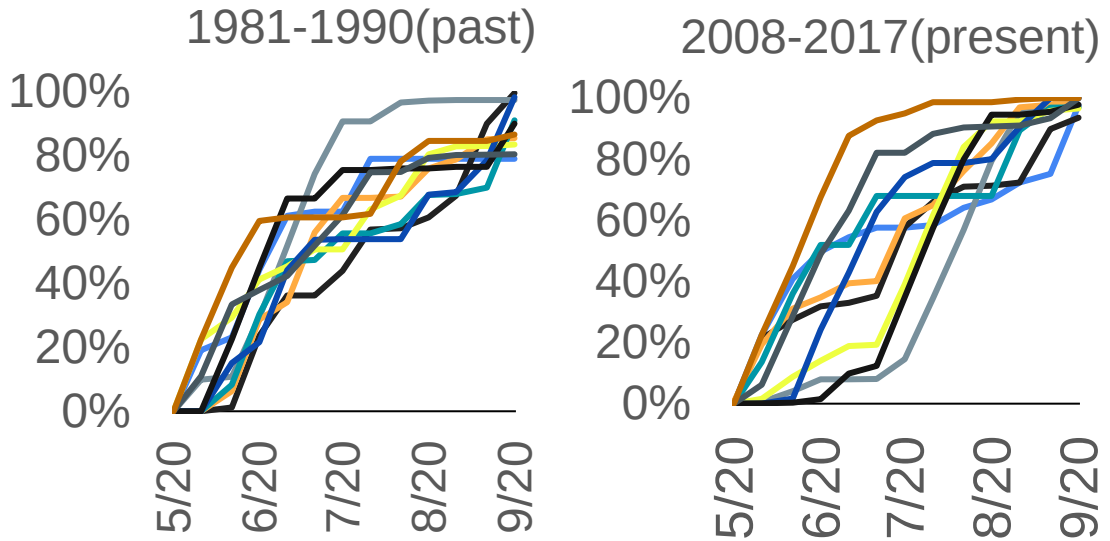


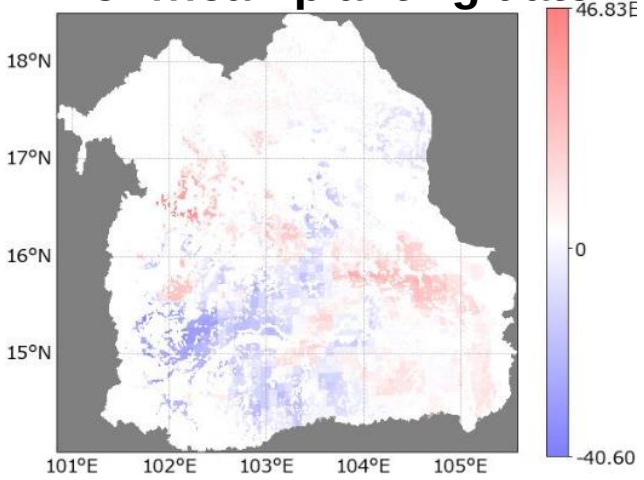
Fig.7 Planted area increase (Left:1981-1990, Right:2008-2017)

Appendix

Change of mean/standard deviation of planting date

- Average and deviation of planting date became **larger in central and southwestern area**, **smaller in southeastern area**.

Dif of mean planting date



Dif of planting date deviation

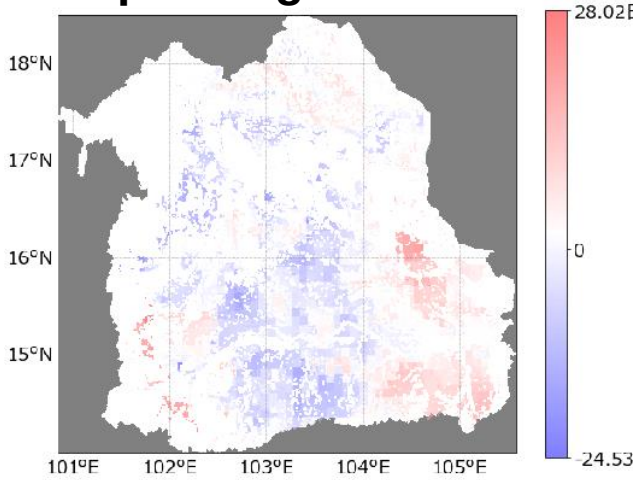


Fig.10 Difference of mean(left) and standard deviation(right) of planting date