Effect of Climate on Spring Phenology and Harvest Dates in Apple cv. 'Fuji' and 'Hongro'

Jung Gun cho[1], Hyun Hee Han[2], Sunil Kumar[1], Patrick Martin[1] and Han Chan Lee[2]

[1]Colorado State University, Fort Collins, CO
[2]National Institute of Horticultural & Herbal Science,
Rural Development Administration, Wanju-gun, Republic of Korea

Introduction

Apple 'Fuji' and 'Hongro' are important cultivars in the fruit industry in Korea. Climate changes are forecasted that they would affect apple trees' phenological changes. With 4 years' recent observation data across Korea, we found some models and mapped with them for predicting future changes. Spring phenology such as budburst and full bloom were well related with the variables which we considered in this study while the harvest date could not be found the relationships with the variables.

Material and Method

❖ Research sites
- 41 sites: orchards or research stations
❖ Survey Period: 4 years(2011~2014)
❖ Cultivars and dependent variables
- 'Fuji' and 'Hongro' apples
- Budburst, Flowering, Full bloom, and Harvest
❖ Explanatory variables
- Temperature in March(T_{MAR}), Precipitation in March(P_{MAR}), Bioclim11(BIO11), Growing degree days(GDD), Latitude(Lat), Elevation(Elv)
❖ Prediction with the future climate scenarios
- RCP 4.5 and RCP 8.5
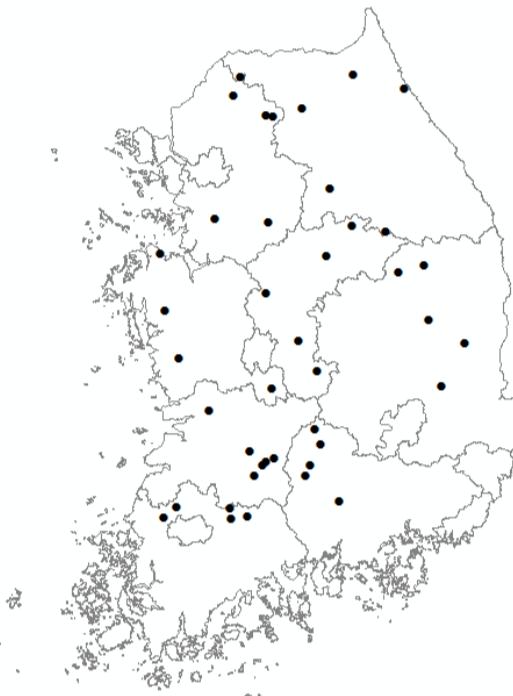
Results
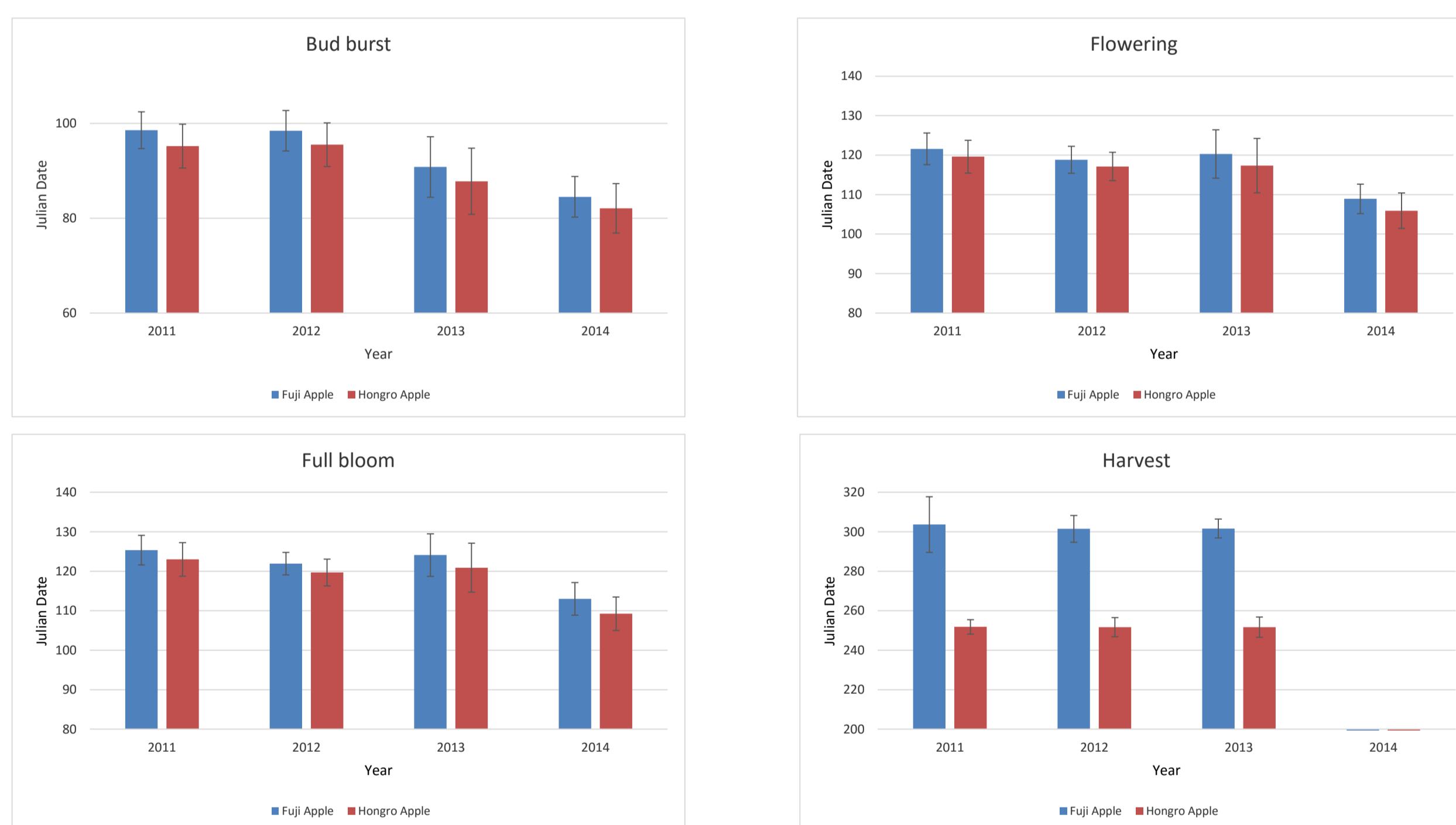
Figure 1. Spring phenology and harvest dates in Apple 'Fuji' and 'Hongro'

Table 1. Models evaluated for the budburst date of 'Fuji' Apple

No	Variables	No. of variables	AIC	ΔAIC	Adjusted R₂
1	T_{MAR}, P_{MAR}, Elv	3	172.53	0.00	0.78
2	T_{MAR}, P_{MAR}, GDD	3	172.82	0.29	0.78
3	T_{MAR}, P_{MAR}	2	173.38	0.84	0.77
4	T_{MAR}, P_{MAR}, BIO11, Elv	4	173.66	1.13	0.78
5	T_{MAR}, P_{MAR}, GDD, Elv	4	174.33	1.80	0.77
6	T_{MAR}, P_{MAR}, BIO11, GDD	3	174.56	2.03	0.77
7	T_{MAR}, P_{MAR}, BIO11	3	175.36	2.83	0.76
8	T_{MAR}, P_{MAR}, BIO11, GDD, Lat	5	176.21	3.68	0.77
9	T_{MAR}, P_{MAR}, BIO11, GDD, Lat, Elv	6	177.47	4.94	0.76
10	T_{MAR}	1	187.26	14.73	0.67

Table 2. Models evaluated for the full bloom date of 'Fuji' Apple

No	Variables	No. of variables	AIC	ΔAIC	Adjusted R₂
1	T_{MAR}, P_{MAR}, Elv	3	169.78	0.00	0.82
2	T_{MAR}, P_{MAR}, BIO11, Elv	4	169.86	0.08	0.82
3	T_{MAR}, P_{MAR}	2	171.13	1.35	0.81
4	T_{MAR}, P_{MAR}, BIO11, GDD, Elv	4	171.18	1.40	0.82
5	T_{MAR}, P_{MAR}, GDD, Elv	4	171.33	1.55	0.82
6	T_{MAR}, P_{MAR}, GDD	3	172.08	2.30	0.81
7	T_{MAR}, P_{MAR}, BIO11, GDD, Lat, Elv	6	172.20	2.43	0.82
8	T_{MAR}, P_{MAR}, BIO11	3	173.09	3.32	0.80
9	T_{MAR}	1	188.16	18.38	0.70

Table 3. Models evaluated for the budburst date of 'Hongro' Apple

No	Variables	No. of variables	AIC	ΔAIC	Adjusted R₂
1	T_{MAR}, P_{MAR}, GDD	3	187.50	0.00	0.80
2	T_{MAR}, Elv	2	188.52	1.02	0.79
3	T_{MAR}, P_{MAR}, Elv	3	189.30	1.81	0.79
4	T_{MAR}, P_{MAR}, GDD, Elv	4	189.48	1.98	0.80
5	T_{MAR}, P_{MAR}	2	190.88	3.38	0.78
6	T_{MAR}, P_{MAR}, BIO11, GDD, Lat	5	191.10	3.60	0.79
7	T_{MAR}, P_{MAR}, BIO11, GDD, Elv	5	191.38	3.88	0.79
8	T_{MAR}, P_{MAR}, Latitude	3	192.40	4.90	0.78
9	T_{MAR}, P_{MAR}, BIO11, GDD, Lat, Elv	6	193.10	5.60	0.79
10	T_{MAR}	1	204.53	17.03	0.69

Table 4. Models evaluated for the full bloom date of 'Hongro' Apple

| No	Variables	No. of variables	AIC	ΔAIC	Adjusted R₂
1	T_{MAR}, P_{MAR}, GDD	3	180.23	0.00	0.82
2	T_{MAR}, P_{MAR}, GDD, Elv	4	181.99	1.75	0.81
3	T_{MAR}, P_{MAR}	2	182.01	1.77	0.81
4	T_{MAR}, P_{MAR}, BIO11, GDD	3	182.23	2.00	0.81
5	T_{MAR}, P_{MAR}, Elv	3	182.53	2.30	0.81
6	T_{MAR}, P_{MAR}, BIO11	3	183.46	3.22	0.80
7	T_{MAR}, P_{MAR}, BIO11, GDD, Latitude	5	183.63	3.40	0.81
8	T_{MAR}, P_{MAR}, BIO11, GDD, Elv	5	183.90	3.67	0.81
9	T_{MAR}, P_{MAR}, BIO11, GDD, Latitude, Elv	6	184.79	4.55	0.81
10	T_{MAR}	1	200.23	20.00	0.69
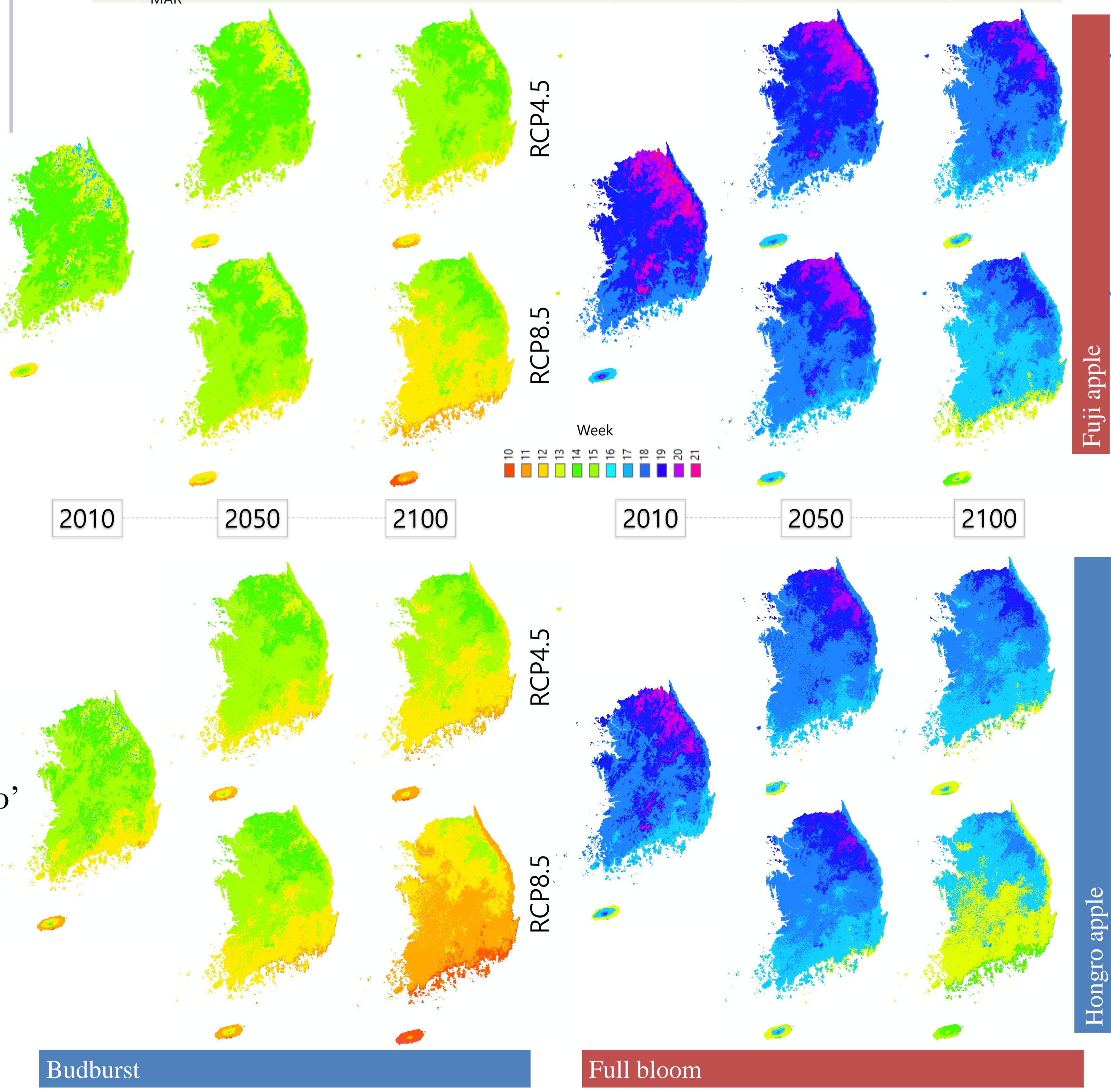
Figure 2. Mapping with climate normals(1981~2010) and the climate scenarios of RCP 4.5 and 8.5

Table 5. Best models for 'Fuji' and 'Hongro' apples

Dependent variable		Predictor	Parameter estimate	P	Adjusted R²	df	F	P
'Fuji' Apple	Budburst	T_{MAR}	-1.42138	0.0133	0.77733, 37		47.55	<0.0001
		P_{MAR}	-0.11118	0.0004				
		Elv	0.007902	0.1115				
	Full bloom	T_{MAR}	-1.61072	0.0042	0.81923, 37		61.4	<0.0001
		P_{MAR}	-0.11954	0.0001				
		Elv	0.008316	0.0842				
'Hongro' Apple	Bud Burst	T_{MAR}	-4.60483	<0.0001	0.80223, 37		55.08	<0.0001
		P_{MAR}	-0.06563	0.0068				
		GDD	0.006832	0.0286				
	Full bloom	T_{MAR}	-4.00829	<0.0001	0.81763, 37		60.79	<0.0001
		P_{MAR}	-0.07603	0.0008				
		GDD	0.005185	0.0668				