Long-term trends of phenological events in Japan

Summary of "Report on Climate Change 2005"

Japan Meteorological Agency

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The Japan Meteorological Agency (JMA) has been observing phenological events since 1953, and today conducts the observations at 87 observatories for 12 botanical species and 11 zoological/entomological species. The phenological observations are conducted in order to understand the effects of climate on the biosphere and to monitor the overall change of the climate, such as going of seasons.

Phenological observations are made for botanical events (budding, blooming, full blooming, autumnal leaf tint and leaf-falling), and zoological and entomological events (first sighting and first singing) as listed in Table 1.

Table 1 Plants, animals and insects which are the objects of the phenological observations

Plant name	Event
Japanese apricot (*Prunus mume Sieb. Et Zucc*)	Blooming
Camellia (*Camellia japonica L*.)	Blooming
Japanese dandelion (*Taraxacum platycarpum Dahlst., Taraxacum albidum D.*)	Blooming
Cherry (*Prunus yedoensis Matsum*.)	Blooming, Full blooming
Azalea (*Rhododendron kaempferi Planch*)	Blooming
Japanese wisteria (*Wistaria floribunda DC.*)	Blooming
Bush clover (*Lespedeza bicolor Turcz. Var. japonica Nakai*)	Blooming
Hydrangea (*Hydrangea macrophylla Seringe var. otaksa Makino*)	Blooming
Crape myrtle (*Lagerstoemia indica L*.)	Blooming
Silver grass (*Miscanthus sinensis Anderss*)	Blooming
Ginkgo (*Ginkgo biloba L*.)	Budding, Leaf tint, Leaf-falling
Japanese maple (*Acer palmatum Thunb.*)	Leaf tint, Leaf-falling
Animal/insect name	**Event**
Skylark (*Alauda arvensis LINNAEUS*)	First singing
Japanese bush warbler (*Cettia diphone KITTLITZ*)	First singing
Barn swallow (*Hirundo rustica LINNAEUS*)	First sighting
Small white (*Pieris rapae crucivora BOISDUVAL*)	First sighting
Swallowtail (*Papilio machaon hippocrates C. et R. FELDER*)	First sighting
Black-spotted pond frog (*Rana nigromaculata HALLOWELL*)	First sighting
Commons skimmer (*Orthetrum albistylum speciosum UHLER*)	First sighting
Firefly (*Luciola cruciata MOTSCHULSKY, Luciola lateralis MOTSCHULSKY*)	First sighting
Large brown cicada (*Graptopsaltoria nigrofuscata MOTSCHULSKY*)	First singing
Evening cicada (*Tanna japonensis DISTANT*)	First singing
Bull-headed shrike (*Lanius bucephalus TEMMINCK et SCHLEGEL*)	First singing

When a JMA's observer recognizes any of these events with their eyes or ears, the date of its occurrence is recorded.

Summarized below are the relationship between the botanical phenological events and surface temperatures, and long-term trends of the blooming dates of cherry blossoms (2005, Japan Meteorological Agency).

1. Relationship between phenological events and surface temperature

The observation shows that growth of plants, or phenological event, has close relationship with surface temperature.

Listed in Table 2 are correlation coefficients between anomalies of the averaged dates of phenological events and those of the surface temperatures averaged for 50 years at 17 meteorological observatories, where influence of urbanization to its climate is less than in urban cities. The table shows that absolute values of correlation coefficients are 0.7 or above for 13 events of nine species, most of which are statistically significant (the level of significance is 5%). Correlations are particularly high for events in spring such as the blooming dates of the Japanese dandelion and the cherry blossom.

Table 2 Correlations between phenological events and surface temperature

Event	Period of surface temperature averaged for 50 years	Correlation coefficient
Japanese apricot, blooming	December - February	-0.75
Camellia, blooming	November - January	-0.74
Japanese dandelion, blooming	February - April	-0.88
Cherry, blooming	February - April	-0.91
Cherry, full blooming	March- April	-0.90
Azalea, blooming	February - April	-0.84
Japanese wisteria, blooming	March - April	-0.90
Ginkgo, budding	March- April	-0.89
Crape myrtle, blooming	May-July	-0.79
Ginkgo, autumnal leaf tint	September - November	0.80
Ginkgo, leaf-falling	October - November	0.82
Japanese maple, autumnal leaf tint	September - November	0.75
Japanese maple, leaf-falling	September - November	0.83

Table 3 shows long-term trends of the phenological events listed in Table 2 (change of the days in 50 years). All trends except those of blooming of Japanese apricot and azalea are statistically significant (the level of significance is 5%).

Table 3　Long-term trends of phenological events

Event	Statistical significance	Number of stations used	Long-term trend (day/50 years)
Japanese apricot, blooming		71	-5.4
Camellia, blooming	*	54	-9.4
Japanese dandelion, blooming	*	70	-6.0
Cherry, blooming	*	82	-4.2
Cherry, full blooming	*	81	-4.3
Azalea, blooming		59	-3.6
Japanese Wisteria, blooming	*	48	+1.1
Ginkgo, budding	*	42	-3.2
Crape myrtle, blooming	*	31	-5.8
Ginkgo, autumnal leaf tint	*	43	+10.7
Ginkgo, leaf-falling	*	39	+5.4
Japanese maple, autumnal leaf tint	*	46	+15.6
Japanese maple, leaf-falling	*	37	+9.1

- A positive (negative) value of "Long-term trend" indicates that the event has become later (earlier).

* denotes that the trend is statistically significant with a level of significance of 5%.

Budding dates and blooming dates in spring have become earlier, while dates of leaf tints and leaf-falling in autumn have become later. In particular, the date of autumnal tint of the Japanese maple has become later by more than 15 days in the last 50 years (Figure 1). Long-term trends of these phenomena, which have close correlation with surface temperature, suggest the impact of the long-term increase in temperature due to global warming.

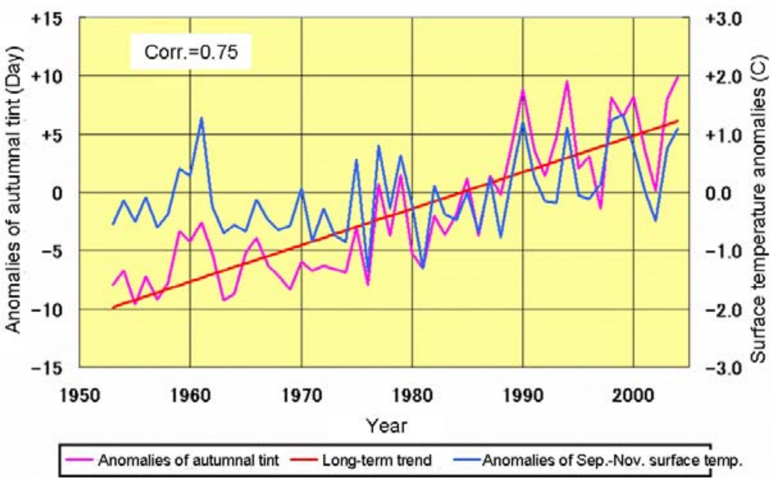

Figure 1　Correlation between surface temperature and autumnal tint of the Japanese maple

With regard to events of blooming and full blooming of cherry, blooming of Japanese Wisteria, budding of Ginkgo and blooming of Japanese dandelion, warm conditions in the last few years led to their earlier-than-usual occurrences and made their long-term trends statistically significant, while statistics until 1997 did not show any statistically significant trends in these events.

2. Long-term trends of the blooming dates of cherry blossoms

The blooming date of cherry blossom averaged over Japan has become earlier by 4.2 days in the last 50 years. This trend is similarly found almost all over Japan.

In such a similar trend, differences are found in the trends of the blooming dates of cherry blossom between urban and rural cities. The trend in the urban cities averaged for six cities (Sapporo, Sendai, Tokyo, Nagoya, Kyoto and Fukuoka) shows that the blooming dates have become 6.1 days earlier in 50 years (Figure 2 left panel), whereas the trend in rural cities averaged for eleven rural cities is 2.8 days earlier in 50 years (Figure 2 right panel). This difference in the long-term trend of blooming dates of cherry blossoms between urban and rural cities suggests that urbanization is one of the factors that affect the plant phenology.

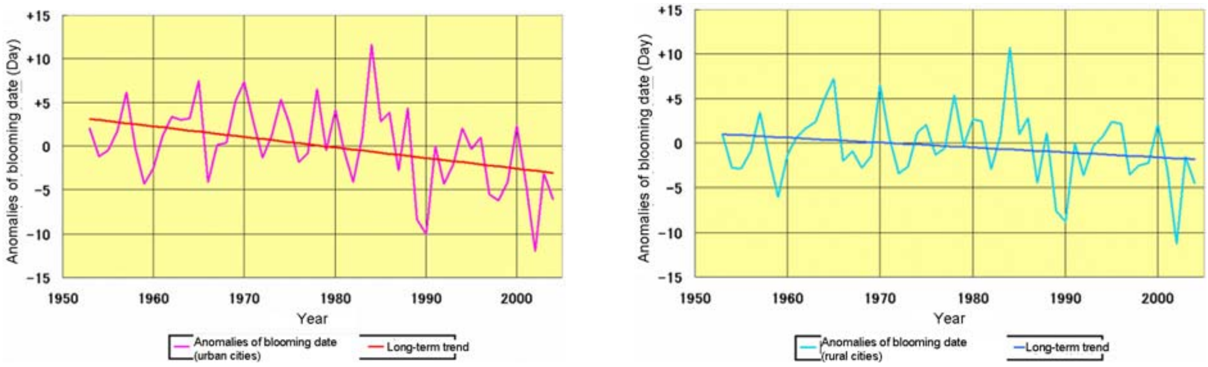

Figure 2 Long-term trends of anomalies of blooming dates (cherry blossoms) in urban cities (left) and in rural cities (right)

Reference

Japan Meteorological Agency (2005): Report on Climate Change 2005, section 2.1.3. (in Japanese)
http://www.data.kishou.go.jp/climate/cpdinfo/climate_change/2005/2.1.3.html

Notes: Definitions of phenological events

- Cherry blossom
  - Blooming date: the first day in a season when five or six blossoms of a sample tree have bloomed.
  - Date of full blooming: the first day in a season when more than 80% of blossoms of a sample tree have bloomed.
- Autumnal leaf tint
  - Date of autumnal leaf tint: the first day in a season when most of leaves of a sample tree have turned red or yellow while green leaves are hardly observed.
  - Date of leaf-falling: the first day in a season when more than 80% of leaves of a sample tree have fallen.