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Spring and autumn temperatures deduced from phenology in Kyoto and Yedo, and their correspondence with solar variation

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The changes in springtime (March) and autumn (October) temperatures were reconstructed applying data for cherry blossoms and maple leaves' autumn-tints phenologies, respectively. Phenological data series in Kyoto and Yedo (Tokyo) were obtained from many old diaries. From many archives, the dates on which phenophase was observed or viewing parties were held, were acquired as noted phenological records.

The full blossoming dates of a native cherry tree species, *Prunus jamasakura*, were applied to reconstruct March mean temperatures in Kyoto and Yedo. Cherry blossom phenological data for 823 years (scattered from 812 to 2011 A.D.) in Kyoto and for 207 years (scattered from 1636 to 1905 A.D.) in Yedo are now available, respectively. Calibration enabled accurate estimation of March temperatures in the instrumental period. The reconstructed March temperature series in Kyoto suggests the presences of a warm period in the 10th century (around 7 degree C, warmer than the present normals of 6.6 degree C, after subtracted the urban warming bias) and four cold periods of 1330-50, 1520-50, 1670-1700 and 1825-30. These cold periods coincided with the less extreme period of solar activity, known as the Wolf, Spoerer, Maunder and Dalton minima. Each cold period has time-lag of climate response of a few ten years to corresponding minimum of solar variation.

Reconstructed March mean temperature series in Yedo since the 17th century shows a similar pattern to that in Kyoto. Especially, two cold periods in the late-17th and in early-19th centuries in both cities clearly appeared in each reconstructed temperature series. The spring temperatures in Maunder and Dalton minima in Kyoto were almost the same, while those in Yedo showed 1 degree C difference. In Yedo, the estimations in Maunder minimum were about 4 degree C, 1 degree C colder than those in the Dalton minimum.

Another attempt to reconstruct October mean temperature in Kyoto was made by applying of phenological data for autumn-tints of maple (*Acer* spp.) leaves, which were available for 478 years after 1200 A.D. Autumn temperature series partially showed similar pattern to springtime temperature series. A cooling trend over the 15th-16th centuries was commonly detected in October and March temperature series, however, October temperature change preceded March temperature change by about 10 years. It suggests that the time-lag of climate response of October temperature in Kyoto to the solar variation might be smaller than that of March temperature.

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