Earlier onset of spring: quantifying from temperature series in Stockholm and northern China

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1. Introduction

Changes in the timing of seasons, especially the spring season, under global warming have gained much attention worldwide in recent decade or so. The timing of the spring season has a large influence on natural ecosystems and human activities such as agricultural planning, including spring sowing and cultivation of plantation and poultry, and spring tourism. Since temperature records are easily available and comparable across a larger area, in this study we quantifying trends in the timing of climatic spring onset, as well as its possible causes from both long-term and short-term perspectives and exploring possible predictors for the timing of spring onset. The target region is chosen in Stockholm, where one of the longest climate series in the world, i.e., the daily temperature records back to 1756 was recorded, and northern China, where a significant warming trend prevailed during the last 50 years.

2. Data and Methods

Data: (1) observed daily mean surface air temperature (**SAT**) records at Stockholm, Sweden from 1756 to 2000, which has been homogenized (Moberg et al. 2002); (2)The China homogenized historical daily mean SAT datasets of 1951–2004, from which 72 stations in northern China (north of 35° N).

Methods: the adaptive and temporally local time-series analysis tool - Ensemble Empirical Mode Decomposition (**EEMD**) (Wu and Huang, 2009) is applied to filter out high frequency fluctuations (HF) and obtain the annual cycle and longer timescale component (**ALC**) from a daily mean SAT series (Fig. 1). The timing of spring onset is uniquely determined as the date of the first intersection of 5℃ threshold (widely adopted) with the low-frequency part of daily SAT series containing the annual cycle and longer timescale components (Fig. 2).

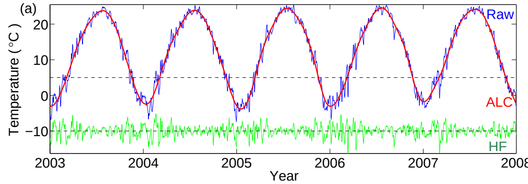

Fig. 1 A diagram of the process of decomposing daily SAT series at Beijing using the EEMD method.

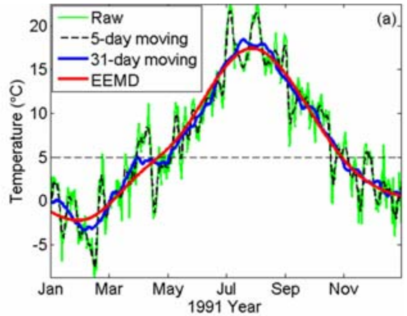

Fig. 2 Comparisons of different methods in determining the onset of the climatic spring season from daily SAT series in 1991 at Stockholm.

Note: 5-day/30-day moving approach has multiple choice of intersection with threshold.

3. From long-term perspective: Stockholm case

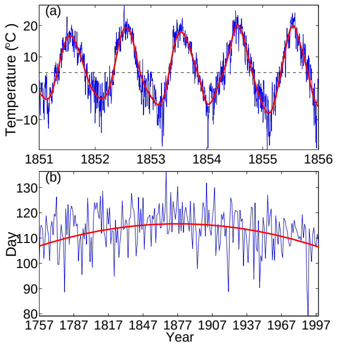

Fig. 3 Changes in the timing of spring onset for 1756-2000

Conclusion: A clear turning point of secular trend in the timing of spring onset around 1884/1885, from delaying to advancing, is found. The winter NAO indices are found to be correlated with the spring onset at Stockholm at an interannual timescale only for some decades, but unable to explain the change of the long-term trends. The secular change from cooling to warming around the 1880s, especially in terms of spring temperature, might have led to the secular change of spring onset (Qian et al. 2009 *GRL*).

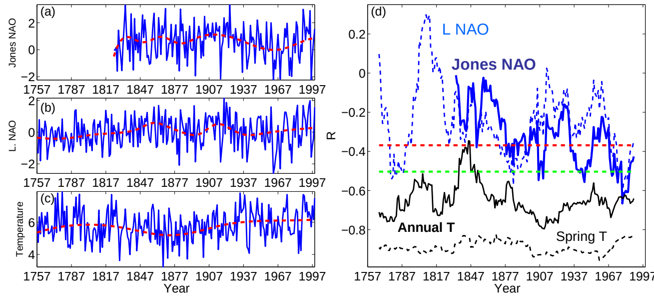

Fig. 4 (a-c) Low-pass filtering of NAO and mean temperature series using EEMD method. (d) 21-year running correlation between spring onset and Jones NAO index, Luterbacher NAO index and mean temperature.

4. Recent decades: northern China case

Background: A tendency of warming shift for the whole seasonal cycle under global warming.

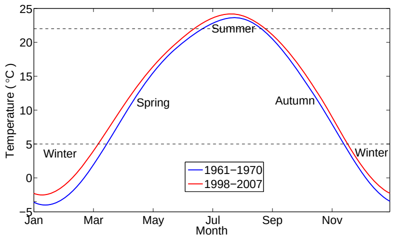

Fig. 5 Comparisons of mean ALC for 1961-1970 (blue) and that for 1998-2007 (red).

Trends in the timing of spring onset and Potential Predictor

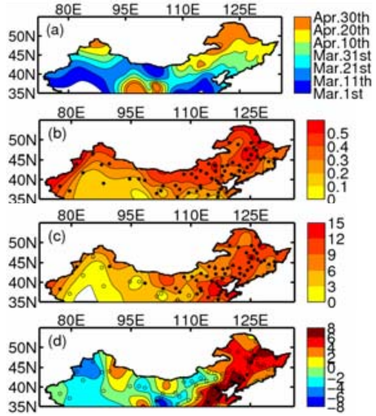

Fig. 6 (a) mean spring onset date; (b) warming trend (℃/decade); (c) trend in spring onset (days/49years); (d) trend in spring onset due to change in the annual cycle only.

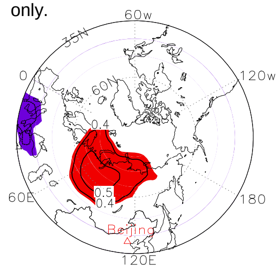

Fig. 7 Predictor for spring onset at Beijing

Conclusion: The spring onset has advanced all over northern China, but more significant in the east than in the west part of the region, which can be explained by opposite changes in the spring phase of the SAT annual cycle (the yearly period component, which is the dominant component in the SAT series outsides the tropics). Change in the spring phase of annual cycle explains 40-60% of the spring onset trend and is attributable to a weakening Asian winter monsoon. (Qian et al. 2011)

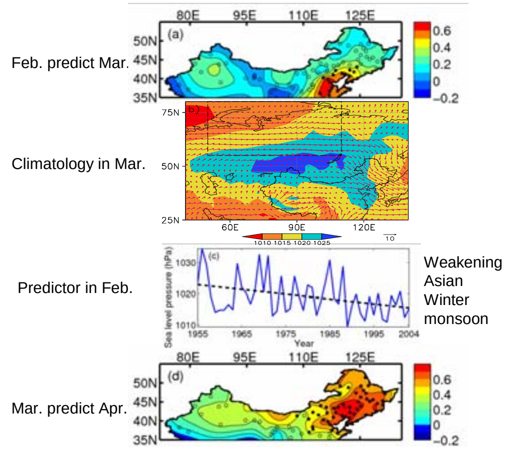

Fig. 8 Predictor and potential predictable regions.

References

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