Using NCEP/NCAR reanalysis data to study the potential predictor for the timing of spring onset in North and northeastern China

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Background

Growing season length is one of the most notable climate indices for studying climate change. Many studies have reported an extended growing season at mid-high latitudes, mainly due to an earlier onset of spring. 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. Therefore, predicting the onset of spring is of significant socioeconomic importance. In this study, the sea level pressure (SLP) and wind at 850 hPa from NCEP/NCAR reanalysis data are used to study the atmospheric circulation pattern in East Asia during winter/spring transition time and potential predictor for the timing of spring onset in North and northeastern China.

Data and Methods

Data: 1. The China homogenized historical daily mean surface air temperature (**SAT**) of 1951–2004;
2.NCEP/NCAR reanalysis data (SLP and wind at 850hpa) for the period 1951-2004
Methods: the adaptive and temporally local time-series analysis tool - Ensemble Empirical Mode Decomposition (**EEMD**) (Wu and Huang, 2009) is applied to isolate annual cycle from interannual and longer timescale component (Fig. 1). The timing of spring onset is uniquely determined as the date of the first intersection of 5℃ threshold with the low-frequency part of daily SAT series containing the annual cycle and longer timescale components (**ALC**) (Fig. 2).

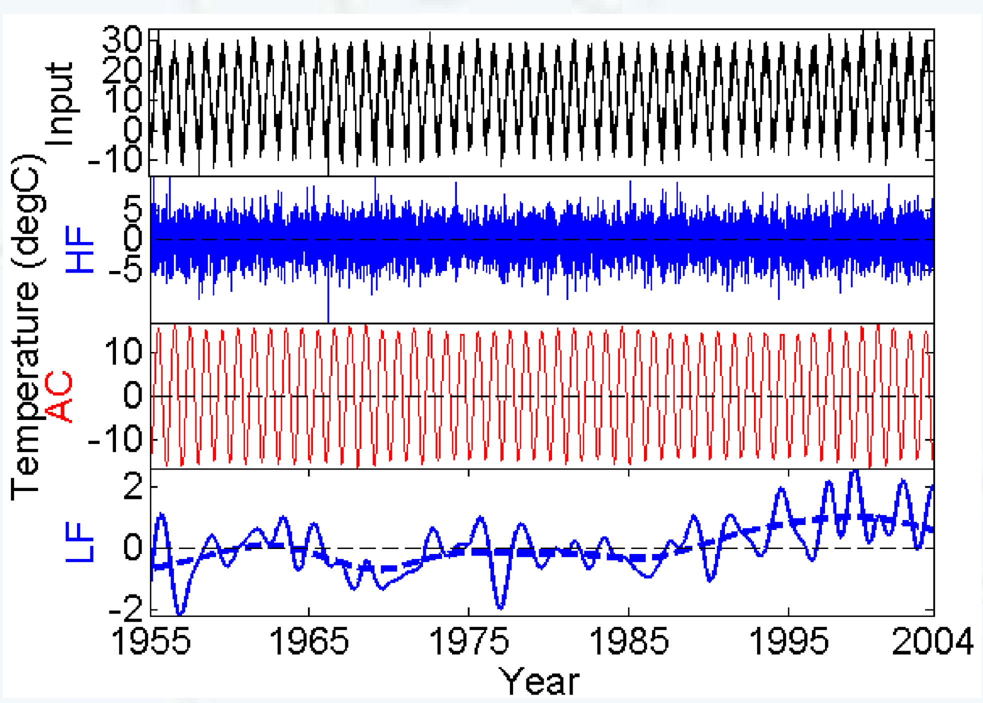


Fig. 1 A diagram of the process of decomposing daily SAT series at Beijing using the EEMD method. HF: high frequency (intra-annual); AC: annual cycle; LF: low frequency (interannual and longer timescale).

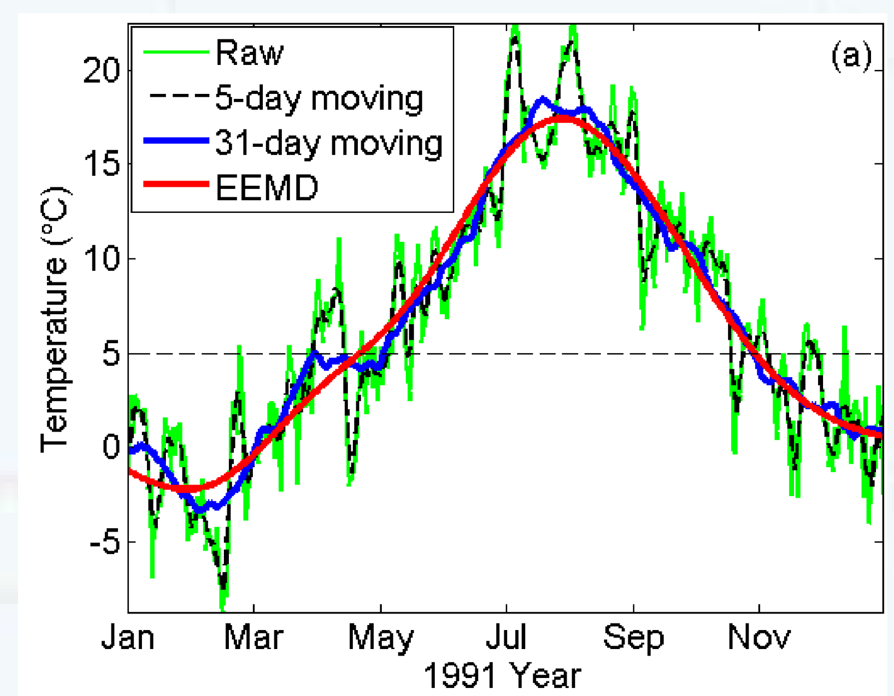


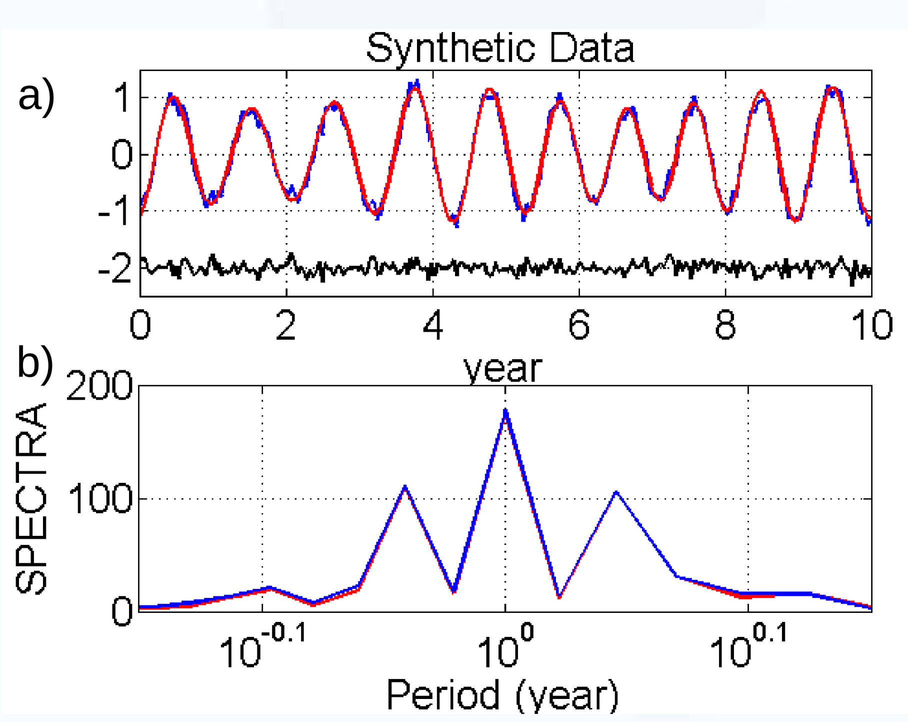
Fig. 2 Comparisons of different methods in determining the onset of the climatic spring season from daily SAT series in 1991 at Stockholm.

Validation of EEMD method in extracting annual cycle

Using EEMD to extract the amlitude-frequency modulated annual cycle (**MAC**) from a niosy synthetic time series (Fig. 3):

$$y(t)=[1+0.2\sin(0.2\frac{2\pi t}{T})]\sin[\theta(t)]+N(t)$$

$$\theta(t)=\frac{2\pi t}{T}+0.03\int_0^t\cos(0.111\frac{2\pi t}{T})dt+\frac{5\pi}{4}$$



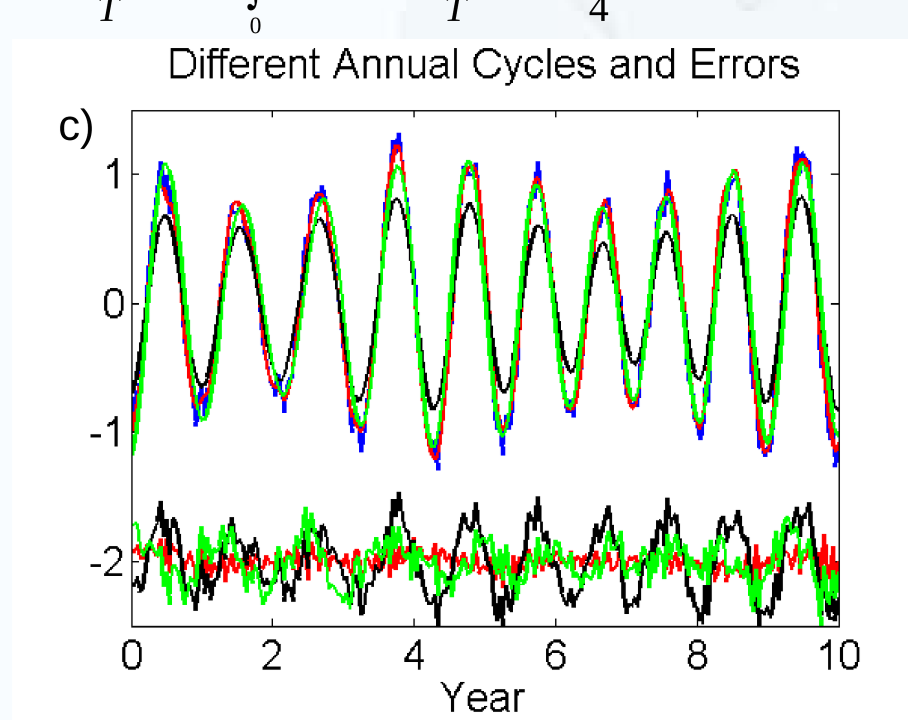


Fig. 3 (a) Synthetic data (blue line), its annual cycle component (red line), and noise (black line). (b) Fourier spectra of the synthetic data (blue line) and its annual cycle (red line). The data are discredited at a rate of one value every half-month. (c) Annual cycles (upper group) extracted using various methods from the synthetic data in (a) and their differences with the synthetic data (lower group). Red lines correspond to using the EEMD method, black lines the running-mean method, and green lines the band-pass method.

Results and Conclusions

Conclusion 1. Spring at Beijing has arrived significantly earlier by about 2.98 day per decade, of which about 1.85 day per decade is due to changes in the annual cycle and 1.13 day per decade due to the long-term warming trend. Variations in the annual cycle could cause as much as a 20-day shift in the onset of spring from one year to another.

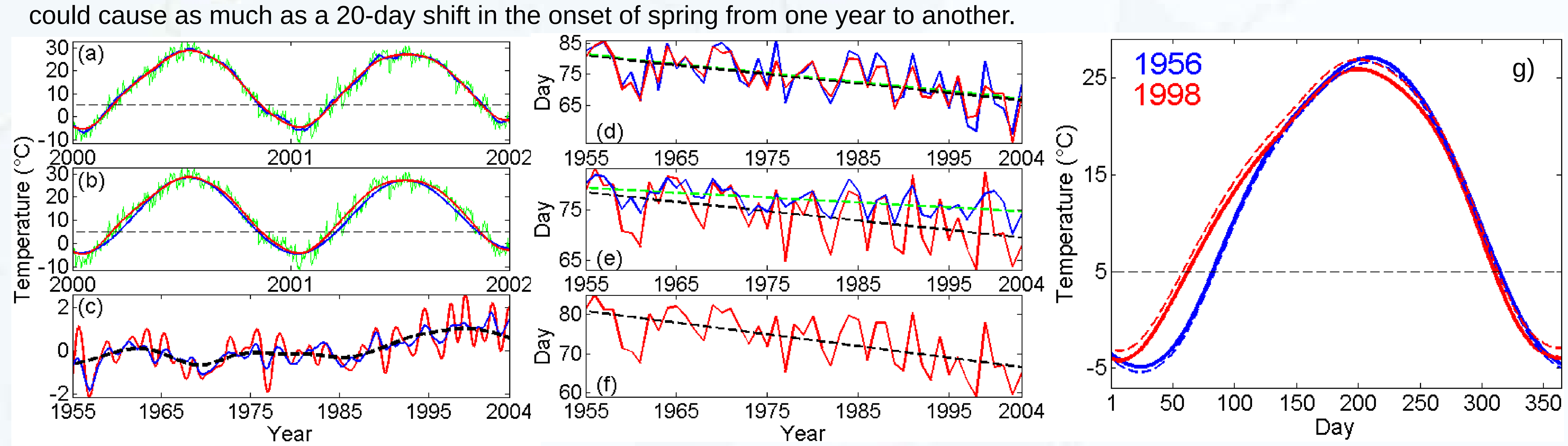


Fig. 4 Panel (a) displays the raw SAT (green line) at Beijing, its 30-day running mean (blue line), the ALC (red line) obtained using EEMD, and the 5ºC threshold line (thin gray dashed line). Panel (b) compares the annual cycle component obtained using EEMD (red line) with that obtained using SSA (blue line). Panel (c) compares the interannual to decadal component obtained using EEMD (red line) with that obtained using SSA (blue line). The decadal trend (black dashed line) obtained using EEMD is also displayed. Panel (d): spring onset dates determined using the ALC (red line) and using the 30-day running mean (blue line), and their corresponding linear trend (dashed black and green line, respectively). Panel (e): spring onset dates associated with the annual cycle obtained using EEMD (red line) and that using SSA (blue line); and their linear trends (dashed black and green line, respectively). Panel (f): spring onset date associated with the combination of the annual cycle component and the adaptive decadal trend obtained using EEMD and the corresponding linear trend (dashed black line). Panel (g): Spring onset dates for 1956 and 1998. Solid lines indicate MAC only, and dotted lines indicate the combination of MAC and the decadal warming trend.

Conclusion 2. The onset of spring has been advancing all over northern China, but at different rates between the east and west parts of the region. These differences are somehow unexplainable by the zonal pattern of the warming trend over the whole region, but can be explained by opposite changes in the spring phase of the MAC, i.e. advancing in the east while delaying in the west. In the east of northern China, the change in the spring phase of MAC explains 40–60% of the spring onset trend and is attributable to a weakening Asian winter monsoon. The average sea level pressure in Siberia (55–80° N, 50–110° E), an index of the strength of the winter monsoon, could serve as a potential short-term predictor for the onset of spring in the east of northern China.

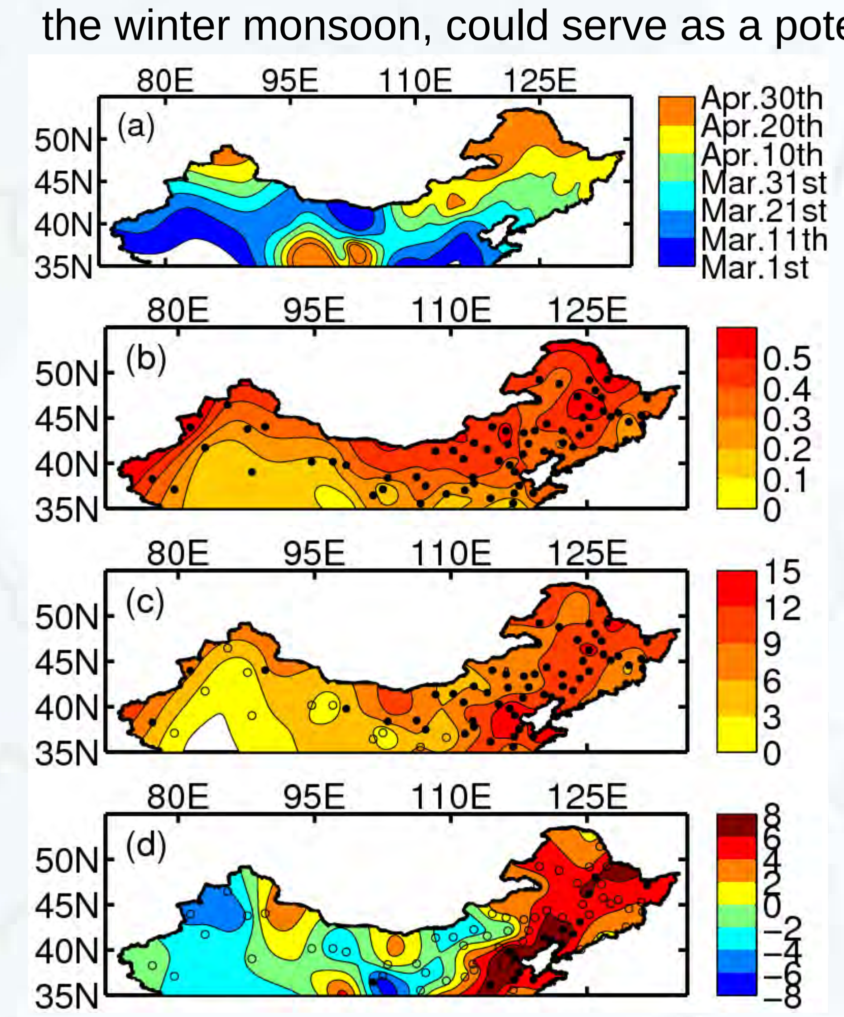


Fig. 5 (a)mean spring onset date; (b)warming trend; (c)trend in spring onset; (d) trend in spring onset due to MAC only.

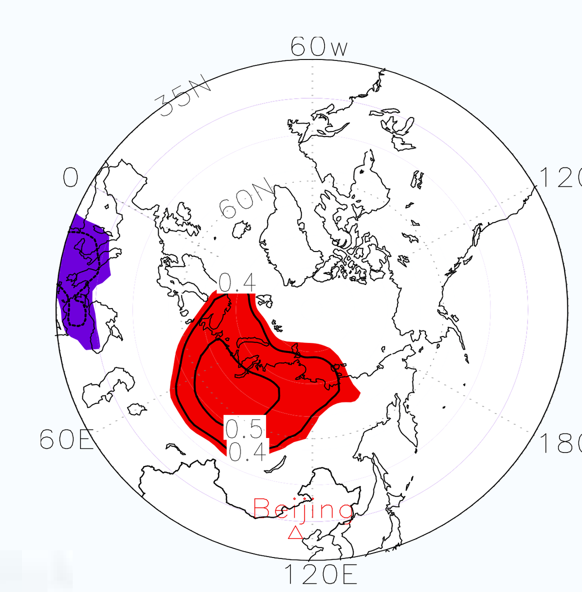


Fig. 6 Predictor for spring onset at Beijing

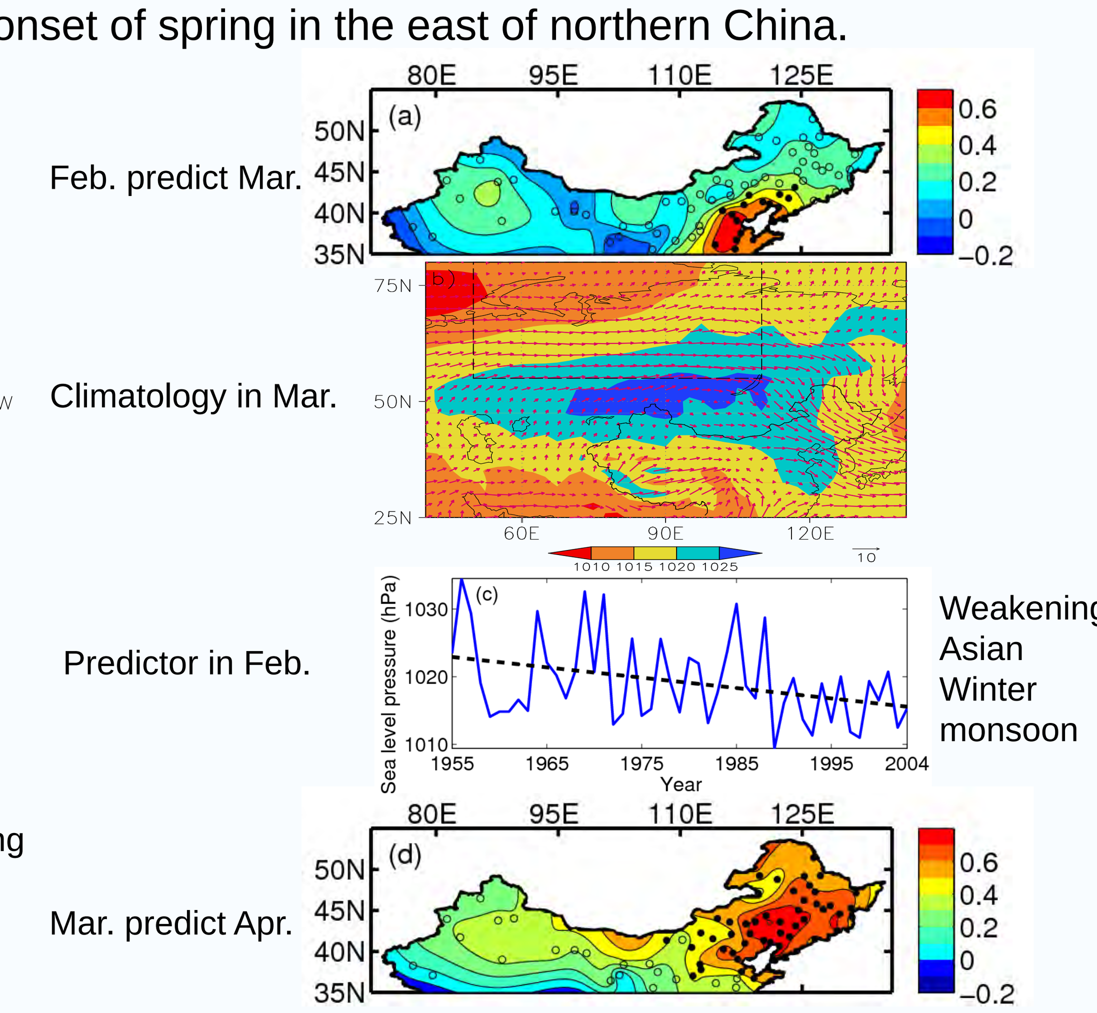


Fig. 7 Predictor and potential predictable regions.

References

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2. Qian C, C Fu, Z Wu, and Z Yan, 2009: On the secular change of spring onset at Stockholm. *Geophys. Res. Lett.*, 36, L12706, doi: 10.1029/2009GL038617