TREND OF NEAR-SURFACE MAXIMUM WIND SPEED IN CHINA: UNDER A SHIFTED EAST ASIAN MONSOON SCENARIO

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ABSTRACT: The current global climate research has traditionally focused on changes in air temperature and precipitation. As a key climate parameter, changes of winds have a very significant impact on the environment, such as soil wind erosion, air pollution diffusion, wind power energy, etc. In particular, changes of extreme wind speed (i.e., wind gusts) are poorly analyzed and deserve further investigation. In this study we assess trends in maximum wind speed (MWS) across China for 1975-2016, using observed daily wind datasets, and also analyze its relationship with the East Asian monsoon. The raw observed MWS dataset was subject to a quality control and robust homogenization protocol using the Climatol package. The results reveal a statistically significant (p<0.05) reduction of MWS of -0.024 m s^{-1} dec^{-1} at annual scale across China, with declines in winter (-0.320 m s^{-1} dec^{-1}; p<0.05) and autumn (-0.090 m s^{-1} dec^{-1}; p<0.05), an opposite increases in summer (+0.272; p<0.05) and spring (+0.034; p>0.10). Even though MWS declines dominated across much of the country throughout the year, only a small number of stations showed statistically significant negative trends in summer (37.7%) and spring (29.0%). Our preliminary analyses show that the weakened East Asian monsoon, particularly in winter, positively correlates with the observed changes in MWS. However, statistical significant correlations are too few and further attribution analyses are strongly needed.

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1. Maximum wind speed data and homogenization

- **Location:** 789 stations across China
- **Wind data:** Daily maximum wind speed (MWS hereafter ; i.e., the highest average 10-minute value in 24 hours)
- **Time period:** 1975-2016 (42-years)
- **Homogenization method**: R package Climatol version 3.0 (http://www.climatol.eu/); SNHT
- **Trend method:** Mann-Kendall test at p<0.05 and p<0.10

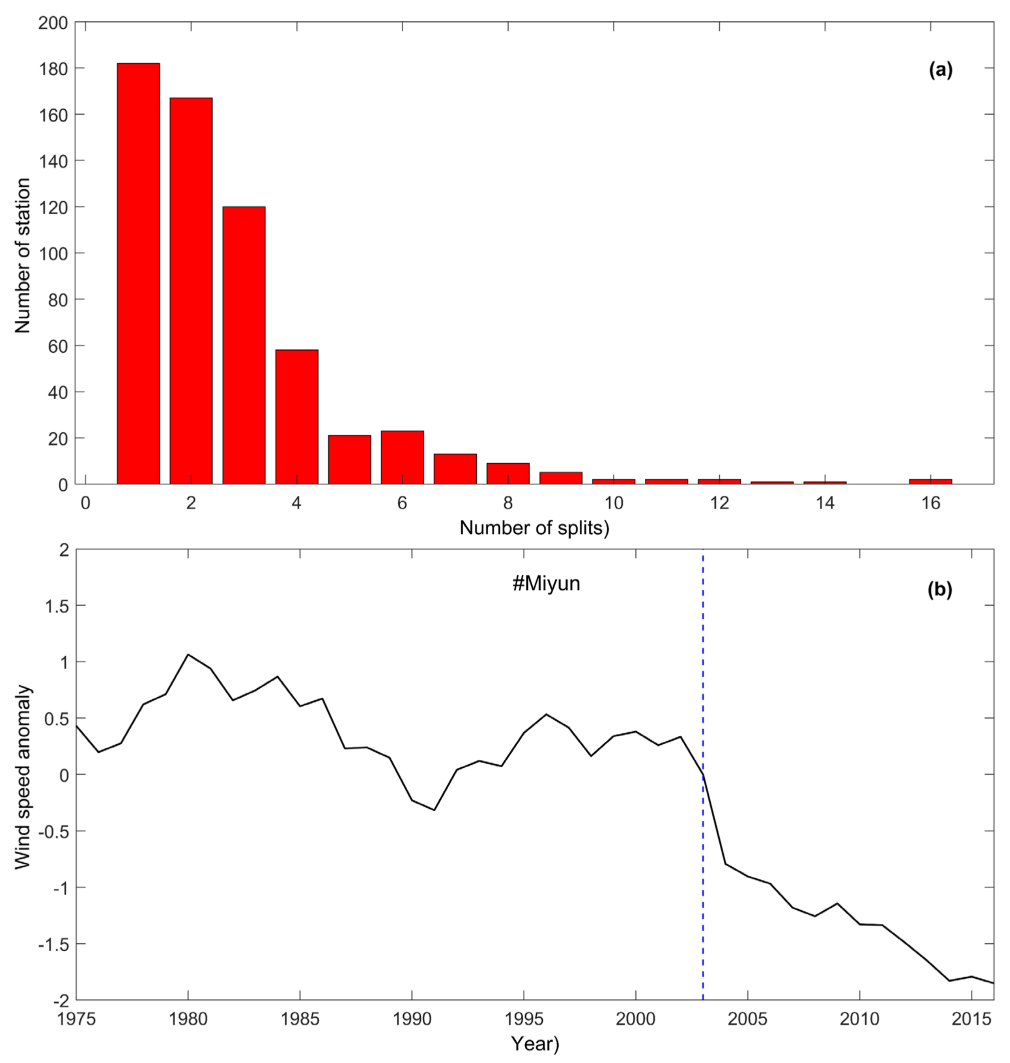

Figure 1. (a) Histogram of the number of stations that have suffered different number of splits due to the detection of break-points on them; **(b)** anomaly series of the Miyun station and detection of the most significant break-point (blue-dashed line with the SNHT value=60), noting that two more break-points with SNHT>25 were corrected in successive iterations.

3. Spatial distribution of MWS trends

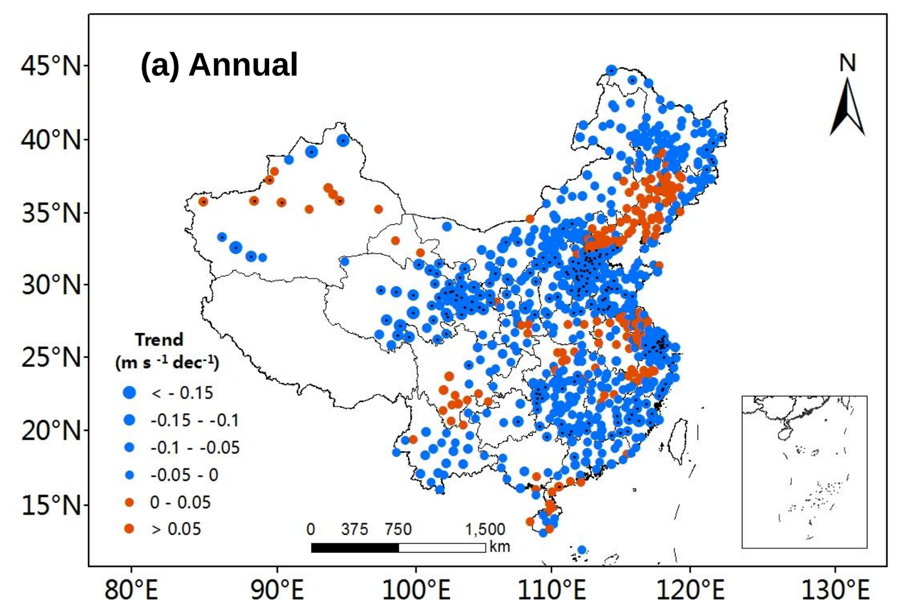

Figure 3. Spatial distribution of the sign, magnitude and statistical significance of MWS trends (in m s^{-1} dec^{-1}) in **(a)** annual, **(b)** winter, **(c)** spring, **(d)** summer, and **(e)** autumn across China for 1975–2016. Dots in the circle indicate significant trends at p<0.05.

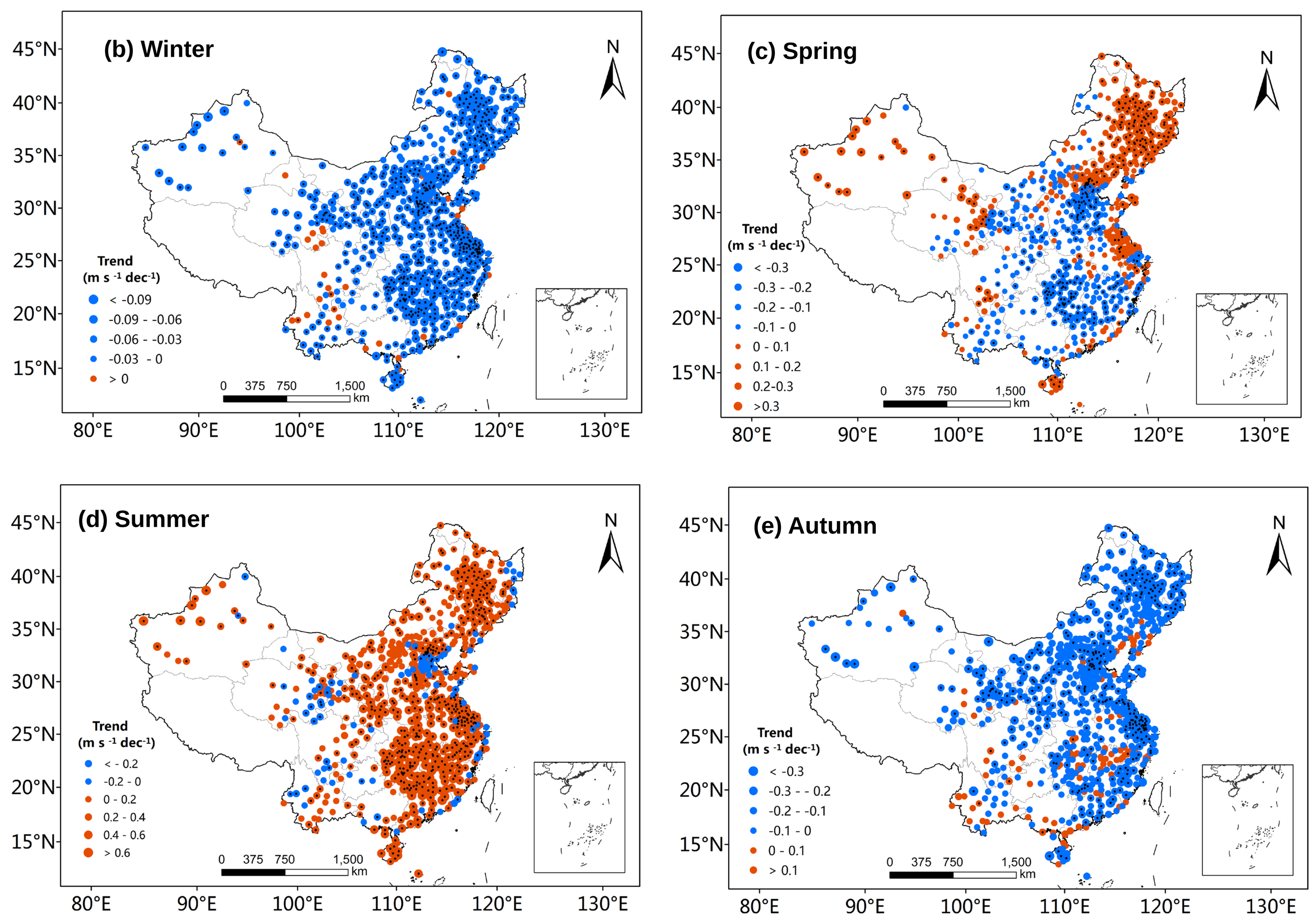

Table 1. Relative frequency (in %) of the stations showing significant (at p<0.05 and p<0.10) and non-significant (at p>0.10) negative and positive MWS trends annually and seasonally across China for 1975-2016.

	Negative	Negative significant p<0.05	Negative significant p<0.10	Negative non-significant p>0.10	Positive	Positive significant p<0.05	Positive significant p<0.10	Positive non-significant p>0.10
Annual	49.1	43.2	51.2	48.8	50.2	49.2	56.8	43.2
Winter	13.6	31.8	39.3	60.6	86.3	74.3	80.8	19.2
Spring	87.0	50.4	60.9	39.1	12.9	5.9	7.8	92.2
Summer	94.9	87.6	90.0	10.0	5.1	10.0	15.0	85.0
Autumn	78.0	31.2	39.4	60.7	21.7	3.5	6.4	93.6

4. Correlations with the East Asian monsoon index

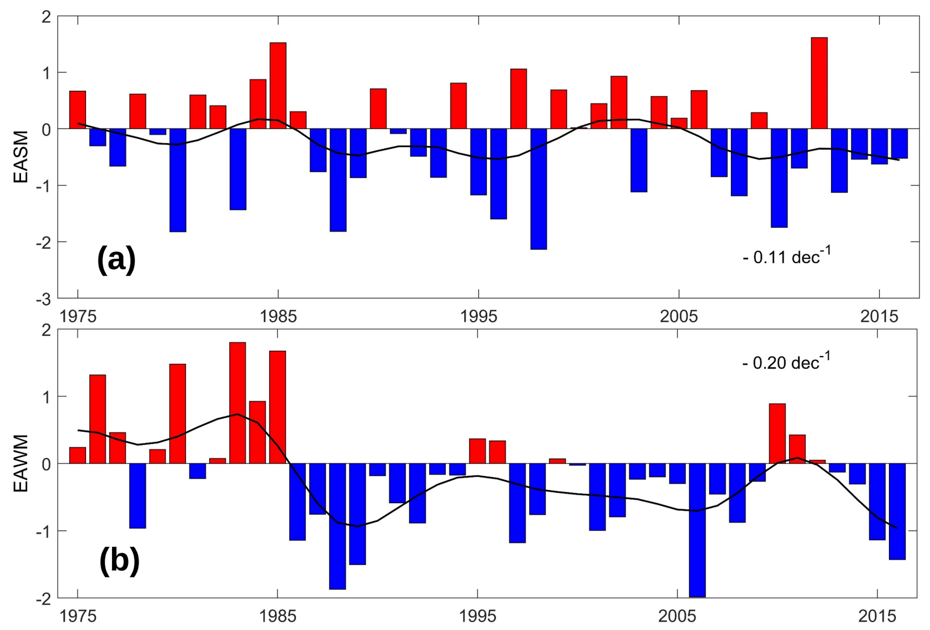

Figure 4. Evolution of East Asian **(a)** Summer monsoon index (EASM), and **(b)** Winter monsoon index (EAWM). Trends in the index are shown.

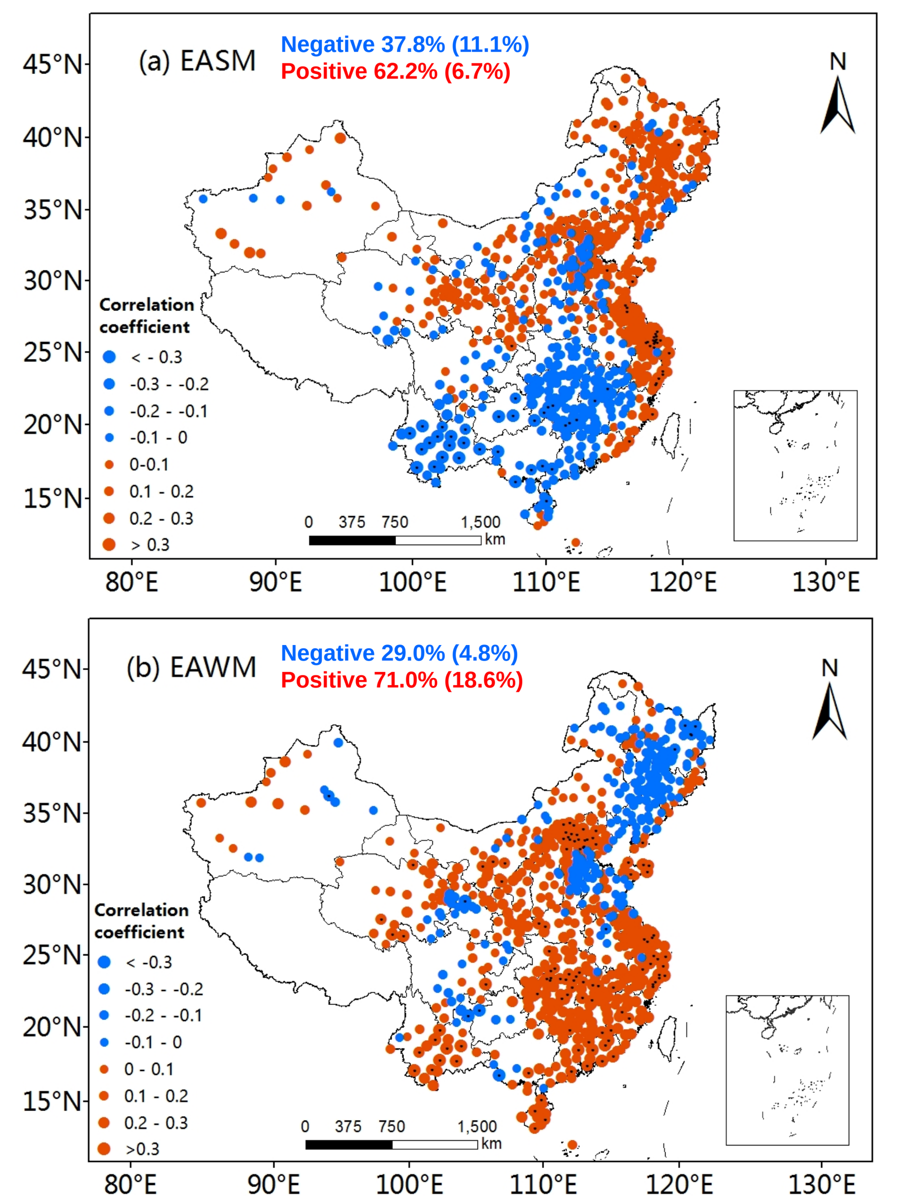

Figure 5. (right) Correlation coefficient map of **(a)** EASM and summer MWS, and **(b)** EAWM and winter MWS. Dots in the circle indicate significant correlations at p<0.10. Relative frequency of negative and positive correlations is also reported with significant ones in brackets.

2. Annual and seasonal trends of MWS

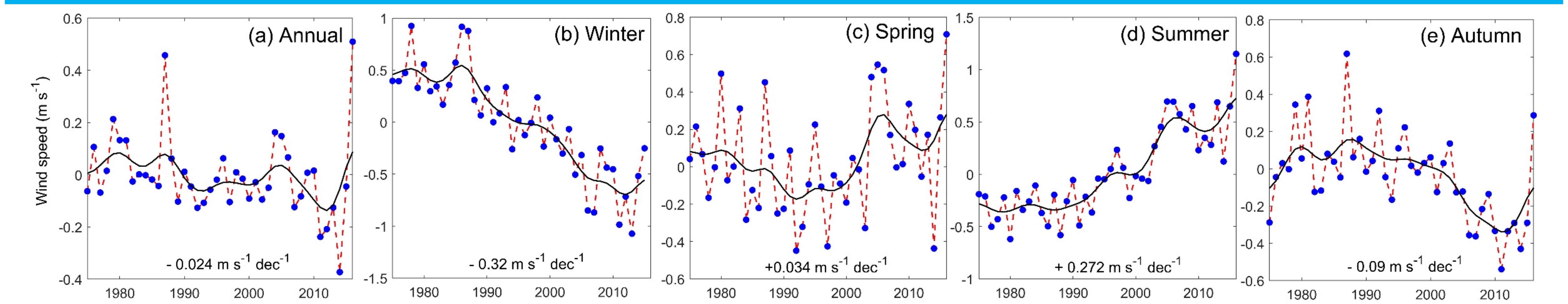

Figure 2. Mean annual and seasonal MWS anomalies (in m s^{-1}) across China for 1975-2016. A 11-year Gaussian low-pass filter is also shown with a black solid line to highlight multi-decadal variability. All series are expressed as anomalies from the 1981–2010 mean.

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5. Discussion and conclusion

1. MWS in China declined significantly (-0.024 m s^{-1} dec^{-1}) at **annual** scale, which was mainly contributed by significant declines in **winter** (-0.320 m s^{-1} dec^{-1}) and **autumn** (-0.090 m s^{-1} dec^{-1}).

2. The opposite positive trend pattern was detected in spring (+0.034 m s^{-1} dec^{-1}) and **summer** (+0.272 m s^{-1} dec^{-1}). This finding is in agreement with some recent studies dealing with the variability of daily peak wind gusts (e.g., Azorin-Molina *et al.* 2016, *JGR-Atmos.*, 121(3), 1059-1078).

3. Spatially, **negative (winter and autumn) and positive (summer) trends dominated across China,** except for **spring when positive trends occurred** over the northeast, northwest and some stations along the coast.

4. EAM positively correlates with MWS variability; however, **only a few number of stations show statistically significant correlations**. This might partly explains the declining of MWS in winter. This dominance of positive relationship is mostly occurring in the northeast and coastal areas during the EASM and across the entire territory except the northeast for the EAWM.

5. Further attribution analyses are strongly needed to better understand spatiotemporal trends in wind extremes, with direct socioeconomic and environmental impacts.