We thank Liu et al. (2019) for their careful reading of our work (Shen et al., 2018). Building on previous studies (Cai et al., 2017; Zou et al., 2017), Shen et al. (2018) found the effect of climate change on winter haze pollution in Beijing is uncertain and likely to be small. One difference with previous studies is that Shen et al. (2018) used relative humidity (RH) as a predictor meteorological variable, based on evidence that high RH is a driving variable for winter haze (Wang Y.S. et al., 2014; Wang Y.X. et al., 2014; Song et al., 2018). Put another way, we focused on the effects of climate change on Beijing haze from a different perspective from previous work.

Fig. 1-2 of Liu et al. (2019) display the trend of annual mean relative humidity (RH) during 1960-2017 from an ensemble of 17 CMIP5 models, arguing that the models cannot reproduce the observed trend. But more relevant to the winter haze problem is to examine RH trends in winter, as was done by Shen et al. (2018) for 1973-2017. There are a lot of missing data in the in-situ meteorological observations before 1973. Pendergrass et al. (2019) found in fact that the CMIP5 models could reproduce the observed wintertime trend of RH during 1973-2016 (see their Figure S3)

Shen et al. (2018) pointed out the strong correlation of wintertime $PM_{2.5}$ in Beijing with the first principal component PC1 of RH and the 850 hPa meridional wind velocity (V850), and subsequently used PC1 as a predictor variable for the effect of climate change on $PM_{2.5}$. Fig. 3 of Liu et al. (2019) shows that the interannual correlation (r) of PC1 and $PM_{2.5}$ is 0.80 during 2010-2017. Liu et al. concluded that this correlation is significantly smaller than the monthly one (r = 0.90) reported by Shen et al. (2018). The Liu et al. (2019) correlation is based on only 8 data points and hence less robust than the one derived by Shen et al. (2018), where individual months can be largely viewed as independent data points. In any case, a correlation coefficient of 0.80 as found by Liu et al. (2019) is still very high and a good basis for future-climate projections.

Fig. 4 of Liu et al. (2019) shows that the correlation of PC1 and $PM_{2.5}$ is only 0.34 when $PM_{2.5}$ concentrations are greater than 150 $\mu g\ m^{-3}$. But we doubt that the authors would be able to find high and robust correlations for such high $PM_{2.5}$ concentrations with any meteorological variables. This is because the high tail of a frequency distribution does not follow Gaussian statistics and reliance on the Pearson correlation coefficient is not recommended. Extreme value theory is a better way to characterize the distribution of high $PM_{2.5}$ in relation to meteorological variables, as presented by Pendergrass et al. (2019) for Beijing winter haze. Indeed, among a variety of meteorological variables, Pendergrass et al. (2019) found that the best fit to the high tail of the $PM_{2.5}$ distribution in a Poisson point process model is RH and V850. Pendergrass et al. (2019) went on to apply their point process model to future climate projections and found no increase in extreme winter haze frequency, consistent with Shen et al. (2018). They found that the only alternative model projecting an increase in haze frequency was one that did not include RH as predictor variable, but that model performed very poorly in the Aikake test.

Liu et al (2019) argue that the PC1 should not be used to exclude other proxies used in previous studies. In fact, Shen et al. (2018) and Pendergrass et al (2019) did consider all the meteorological variables used in Cai et al. (2017) and Zou et al. (2017). See Table S1 and Figures S3-S4 in Shen et al. (2018), and Figures 4 and S1-S2 and related discussion in Pendergrass et al. (2019). Shen et al. (2018) consistently found that these additional variables produced a poorer statistical model than RH and V850 alone. Shen et al. (2018) also discussed why we did not ultimately use zonal wind at 500 hPa (U500) and the temperature gradient between 850 and 250 hPa to infer future trends of $PM_{2.5}$ (Figure S11 and Section 5).

Finally, we thank Liu et al. (2019) for drawing attention to the uncertainty in RH trends. Climate models project a general decrease of RH across eastern China in the future (Byrne and O'Gorman, 2013; Lau and Kim, 2015), but we acknowledge that the uncertainty could be large on a smaller, regional scale as in Beijing.

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