Heavy air pollution suppresses summer rainstorms in central China

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Introduction

By altering radiation budget, heating rate and serving as cloud condensation nuclei (CNN), aerosols can alter cloud properties, precipitation and storms. Various effects are often tangled with varying meteorological conditions. Unraveling the effects has been a daunting task in studying aerosol's direct and indirect effects.

Taking advantage of long-term (50 years) meteorological measurements in central China where distinct contrast in aerosol loading between the Plains and nearby high mountain provide a natural test bed to help isolate various effects by examining the long-term trends and relative changes between the plain and mountain regions and diurnal variations. Since aerosol is confined primarily to the PBL, its alternation to atmospheric stability is opposite near the top and bottom of the PBL. Yet, aerosol direct effect is much stronger during daytime than daytime. By such principles, we investigate the differences in the trends at the plain site of Xian and a nearby mountain site at Hua Mountain. As the two sites are influenced by the same background meteorology, aerosol effects standout more clearly from their relative changes by removing/lessening their natural variability.

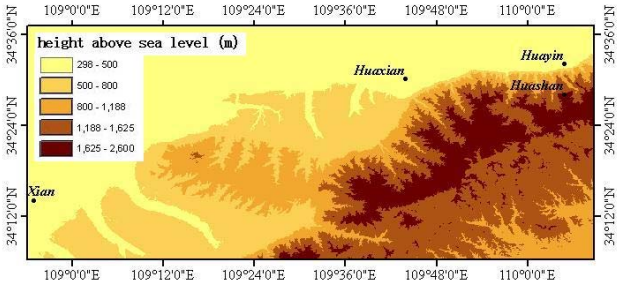

Fig. 1 The Study area in central China. The height of Mt. Hua is 2064.5m, whereas the height of Xian station is 400m.

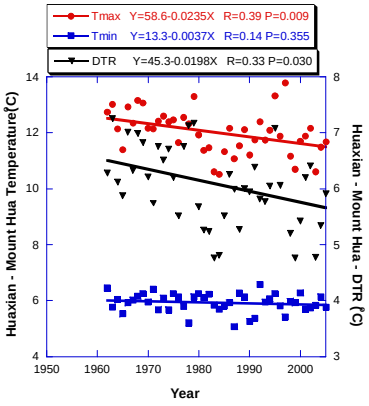

Fig. 2 The JJA trend of the temperature differences between the lowland rural station of Huaxian and the nearby highland station of Mount. Hua.
The response of aerosol's negative radiative forcing: the strong relative decrease in the maximum temperature at the lowland with respect to the highland station, while keeping the difference between the minimum temperatures stable.

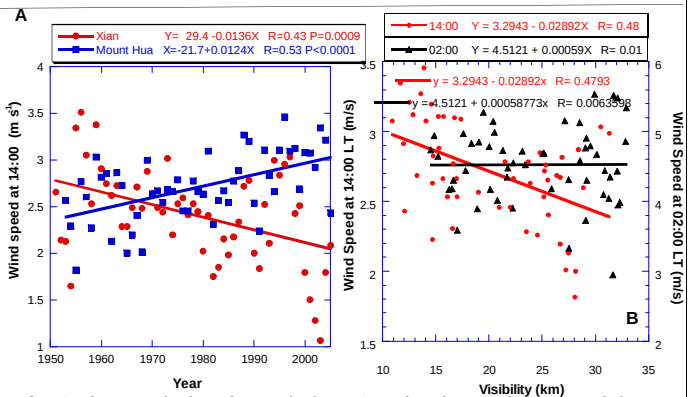

Fig. 3 The trend of surface winds at 2pm in Xian and Mt. Hua (A), Correlation of Xian valley winds and Mt. Hua winds with visibility (B).

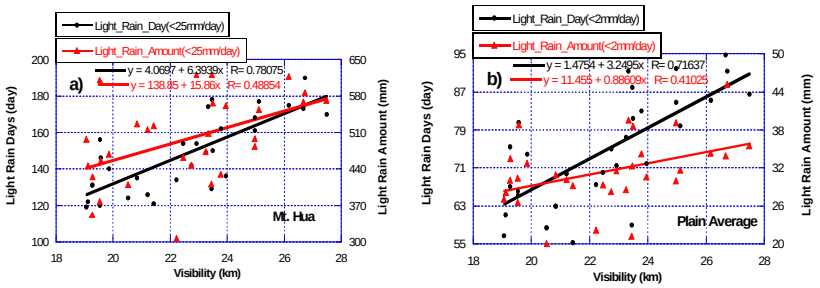

Fig. 4 Correlation between light rainfall rate, light rainfall amount and daily visiblity for Mt. Hua (a) and Xian valley (b). The loss of precipitation at Mt. Hua is much greater than the surrounding plains, due to the aerosol's microphysical effects.

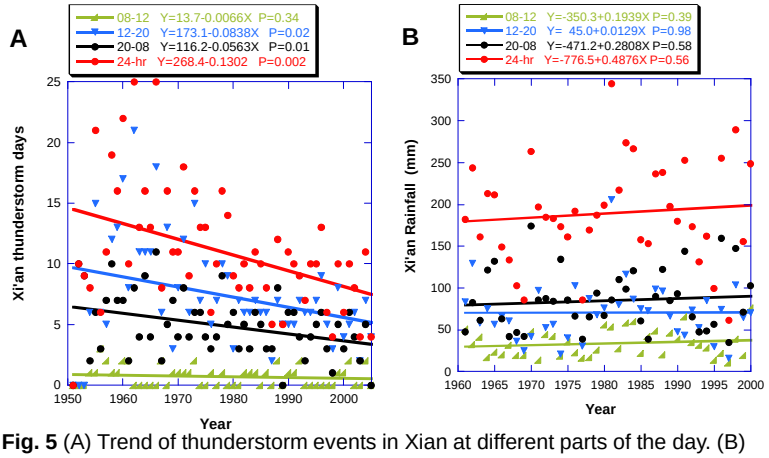

Fig. 5 (A) Trend of thunderstorm events in Xian at different parts of the day. (B) The trend of rainfall in Xian at different parts of the day.

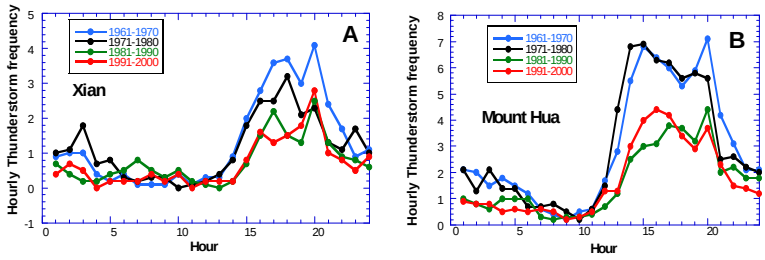

Fig. 6 The dirunal cycle of thunderstorms for 1961-70, 1971-80,1981-90 and 1991-00 for, (A) Xian, (B) Mt. Hua.

Summary:

- Aerosol's negative radiative forcing stabilizes the lowest troposphere.
- The stabilization results in less vertical exchanges of air, which causes a reduction in a decrease and increase of wind at low and upper bounds of PBL.
- The decreased instability causes a decrease in the frequency of the thunderstorms normalized by rainfall amount in the lowlands.
- The decreasing trend of precipitation at highland was associated with a decreasing trend in thunderstorm frequency.
- The patterns of rainfall changes in the highland are consistent with the the suppressing effect of aerosols.

Publications:

Yang et al, 2013, Heavy air pollution suppresses summer thunderstorms in central China, *Journal of Atmos. & Solar-Terrestrial Phy*, 95–96, 28–40

Yang et al. New evidence of orographic precipitation suppression by aerosols in cnetral China, *Meteorol Atmos Phys*, 2013.doi:10.1007/s00703-012-0221-9.

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