

### **Overview of article:**

**Referee:** *“This manuscript presents new observational data from a site in Wuqing for the Haze in China project. The measurements provide a useful description of pollutant characteristics for a suburban site allowing for the evaluation “regional” air quality. Broadly, it was found that higher wind speeds typically decreased high primary pollutant concentrations by way of greater mixing. Ozone demonstrated the opposite relationship likely due to increased transport of ozone formed in other regions and an increase in biogenic VOCs concentrations from S-SW source regions. Overall, this manuscript is thorough and contains detailed analysis and description of the NCP regional back ground air quality characteristics. In spite of the detail, there are still a few content and technical suggestions that can improve the quality and readability of this manuscript.”*

**Response:** *We thank the referee for the valuable comments and suggestions.*

### **Minor Comments and Concerns:**

**Referee:** *“The frequency increment method assumes that the North wind is characteristic of background pollutant conditions (this assumption is supplemented by Figures 7 and 8) and therefore the percent increase in regionally polluted events can be calculated by the difference between the North direction and all other directions. This method is only convincing under higher wind speed categories since transport from the relatively pristine Northern air mass is unlikely to reach the Wuqing station. This can be seen in Table 3 for the lower wind speed bins (wind speeds < 2 m/s). For the low wind speeds the primary pollutants demonstrate vastly different frequency increments during the same season across wind directions, while ozone shows little variability during those same conditions. This indicates that local sources of primary pollutants are the likely driver of changes in frequency increment. It may be more convincing simply to leave off the low bin wind speeds from Table 3 or just mention that this method may not be as indicative of regional transport for lower wind speeds.”*

**Response:** *We agree that this method is influenced by local sources of pollutants under lower wind speed bins. However, wind continuity control was applied for the complete wind speed range, thus the continuity of the wind should compensate for its low speed, and still yield some information on the short distance transport of primary pollutants. For O<sub>3</sub>, a secondary pollutant that is highly nonlinear to the concentrations of its precursor gas concentrations, it is not surprising that it does not show according different frequency increments across the wind directions. O<sub>3</sub> has distinct distribution patterns for different seasons, it is not only influenced by transport and mixing, but also by chemical formations, the similar O<sub>3</sub> concentrations can be measured under vastly different precursor gas concentrations. A few sentences were added to make this section clearer.*

**Referee:** *“There was an assumption made in Section 3.5.1 paragraph 5 that states that NO<sub>x</sub> from regional sources is most likely weak. Have you considered PAN as a possible non-local source of NO<sub>x</sub> to Wuqing from Tianjin or Beijing or have other articles described this?”*

**Response:** *There have not been any measurements of PAN in the North China Plain (NCP)*

*yet, thus the PAN concentration standard is still unknown in this region. However, measurements were made in Lanzhou (a polluted city in western China) and Mount Waliguan (Mt. WLG, a GAW station) in the summer of 2006 (Zhang et al., 2009), resulting in average concentrations of 0.76 ( $\pm 0.89$ ) and 0.44 ( $\pm 0.16$ ) ppbv, respectively. The NO<sub>x</sub> level in Lanzhou is comparable to that of the urban areas in the NCP, while the pollution level in Mt. WLG resembles that of Miyun. Assuming that PAN levels are also alike, such low concentrations of PAN might not have significant influences on local NO<sub>x</sub> concentrations, especially during summertime, when PAN is easily dissociated. PAN is more stable under wintertime low temperatures, thus it might be contributing as a possible non-local source. However, the regional background of NO<sub>x</sub> is already very high, the contribution of PAN may not be as important in comparison. Thus, PAN's influence on clean background sites (such as Mt. WLG) seems to be more significant, than at a site such as ours.*

**Reference:**

*Zhang, J., Wang, T., Ding, A.J., Zhou, X.H., Xue, L.K., Poon, C.N., Wu, W.S., Gao, J., Zuo, H.C., Chen, J.M., Zhang and X.C., Fan, S.J.: Continuous measurement of peroxyacetyl nitrate (PAN) in suburban and remote areas of western China, Atmos. Environ., 43(2), 228-237, 2009.*

**Referee:** *“There is a lot mention of the PBL height and mixing, however, no data are provided other than wind speed to quantify or present evidence for the PBL height and mixing argument (such as on page 7137 lines 4-13). It seems reasonable but the suggestion should be taken as such, simply a suggestion and not a central explanation. If possible, present something regarding the PBL height either in a figure or table or just reframe the discussion/conclusion to use less direct language when talking about mixing and PBL height.”*

**Response:** *Thank you very much for your suggestions. Indeed, there are no measurements of the PBL height, so we rephrased the discussions and conclusions using less direct language. In addition, a reference is added to back up the suggestions we make.*

**Referee:** *“On page 7135 lines 4-5, it is stated that “Atmospheric temperature determines how fast molecules can move in the air...” This is not correct. Temperature IS the average kinetic energy of the molecules in air, it does not determine the speed of the molecules in air.”*

**Response:** *The sentence was corrected into: “Atmospheric temperature is the average kinetic energy of molecules in the air; it directly affects the frequency of collision between molecules, on which chemical reactions rely”*

**Referee:** *“The Conclusion section needs to be put in context of prior literature and studies. Seemed to end without commenting on other work and how this particular study fits into HaChi or other literature.”*

**Response:** *The conclusion section was put into context with prior studies and the following short comment was added to show how this study fits into the HaChi special issue:*

*“Overall, this study provides important information on the pollution state and the characteristics of various gas pollutants. CO and SO<sub>2</sub> are closely related to aerosol pollution, O<sub>3</sub> influences the aging of atmospheric aerosols and SO<sub>2</sub> levels may have great impacts on aerosol hygroscopicity, optical properties and CCN activation.”*

**Technical Recommendations:**

**Referee:** “Pg. 7114 line 13: “...in the NCP, relatively higher concentrations” should be changed to “relatively high concentrations” ”

**Response:** *The sentence was modified according to the suggestion.*

**Referee:** “Pg. 7115 lines 2-3: “O<sub>3</sub> is one of major components...and hazardous to vegetation” should be changed to “O<sub>3</sub> is a major component ...and can be hazardous to vegetation” ”

**Response:** *The sentence was modified according to the suggestion.*

**Referee:** “Pg. 7115 first paragraph seems disjointed. The paragraph begins by saying that “Additionally, CO and NO<sub>x</sub> are precursors of ozone. CO is then well discussed, however, immediately after the CO discussion SO<sub>2</sub> is mentioned and the transition to SO<sub>2</sub> chemistry and its importance comes out of nowhere. Need better connected thoughts here.”

**Response:** *The paragraph was restructured and better connected.*

**Referee:** “Pg. 7116 lines 16-18: Reword the sentence “As for chemical reactions...” ”

**Response:** *The sentence was reworded as: “In regard to chemical reactions and transformations...”*

**Referee:** “I was having some issues understanding which direction the winds were coming from. When a wind is coming from the South it should be called a southerly wind; if headed South it should be referred to as a southward wind. Section 3.1 was particularly difficult to read because of this (see pg. 7122 lines 22, 25-26). After reading on it became more apparent that the authors were always referring to the origin of the wind and not the direction it was headed. Make it clearer so that it is more readable.”

**Response:** *To make it more readable, all wind directions that were fully written were changed to southerly, easterly, westerly and northerly, respectively. However many abbreviations were used, so a statement was added in Sect. 2.4 to clarify that wind directions mentioned in the text refer to the direction where winds come from.*

**Referee:** “Pg. 7128 lines 9-10: The sentence “The traffic...” reads as two independent thoughts. Reword.”

**Response:** *The sentence was reworded as: “The traffic in Wuqing is relatively sparse, especially during nighttime, thus CO emissions from vehicle exhaust mostly occur during daytime.”*

**Referee:** “Pg. 7130 lines 13-17: These sentences need to be re-worded. Too many

*independent thoughts in one sentence.”*

**Response:** *Those sentences were reworded into: “In fall, NW and E wind became more frequent, wind speeds were generally higher. CO mixing ratios were the highest under NE to SE directions. Relatively high concentrations were also detected in the SW section. However, except for the ENE sector, CO concentrations decreased with increasing wind speed in all directions.”*

**Referee:** *“Pg. 7130 line 29: Include a citation for SO<sub>2</sub> domestic heating in winter if possible.”*

**Response:** *A citation was added (Lin et al. 2011).*

**Referee:** *“Pgs. 7130-31 lines 29 and lines 1-2: Re-write this sentence. Again too many independent thoughts in one sentence.”*

**Response:** *In summer (Fig. 7b1), SO<sub>2</sub> mixing ratios were generally low. Relatively higher SO<sub>2</sub> concentrations came with local surface winds from SW-SE, which conforms well with the average summertime distribution of OMI SO<sub>2</sub> PBL column.*

**Referee:** *“Pg. 7131 lines 22-23: Re-write the sentence “In the SE sector...” There are too many thoughts in one sentence.”*

**Response:** *Reworded as: “In the SE sector, relatively high NO<sub>x</sub> values persisted throughout all wind speeds, showing a decreasing trend after reaching a peak at 1m s<sup>-1</sup>. This indicates not only the existence of adjacent emission sources, which is most likely the vehicle exhaust in the centre of Wuqing district, but also transport from farther away sources, such as the Tianjin Municipality.”*

**Referee:** *“Pg. 7132 entire last paragraph: Re-write this paragraph since most of the sentences are run on sentences often containing several seemingly unrelated thoughts.”*

**Response:** *The whole paragraph was rephrased to better connect the thoughts.*

**Referee:** *“Pg. 7135 line 18: Reword “..., under which no O<sub>3</sub>...””*

**Response:** *The sentence was reworded as: “The figure also marks the exceedance standard for O<sub>3</sub> (horizontal red dashed line) and the temperature value (vertical red dashed line), below which O<sub>3</sub> never exceeded given standards.”*