**Table 1.** Weather Research and Forecasting model setting

| **Parameters** | **WRF Setting** |
|---|---|
| Version | WRF v3.7.1 |
| Microphysics | WSM 5-class scheme |
| Cumulus Parameterization | Kain-Fritsch |
| Planetary Boundary Layer | YSU scheme |
| Surface Layer | MM5 Monin-Obukhov scheme |
| Land Surface | Unified Noah land-surface model |
| Urban Surface | No |
| Longwave Radiation | cam scheme |
| Shortwave Radiation | cam scheme |
| SST_update | Yes |

**Table 2.** Community Multiscale Air Quality model setting

| **Parameters** | **CMAQ Setting** |
|---|---|
| Version | CMAQ v5.2.1 |
| Chemical mechanism | Cb06 |
| Horizontal advection | Yamo |
| Vertical advection | WRF input |
| Horizontal mixing/diffusion | Multiscale |
| Aerosol | Aero 6 |
| Cloud option | Acm ae6 |
| Emission | TEDS 9.0 |

**Table 3.** Model domain and resolution setting

| | | Domain 1 | Domain 2 | Domain 3 | Domain 4 |
|---|---|---|---|---|---|
| WRF | Vertical Layer | 45 | 45 | 45 | 45 |
| | Grid Size | 91×91 | 166×169 | 223×223 | 223×223 |
| | FDDA | Yes | Yes | Yes | No |
| CMAQ | Resolution | 81 km | 27 km | 9 km | 3 km |
| | Vertical Layer | 6 | 15 | 15 | 15 |
| | Grid Size | 70×80 | 70×80 | 70×80 | 90×135 |

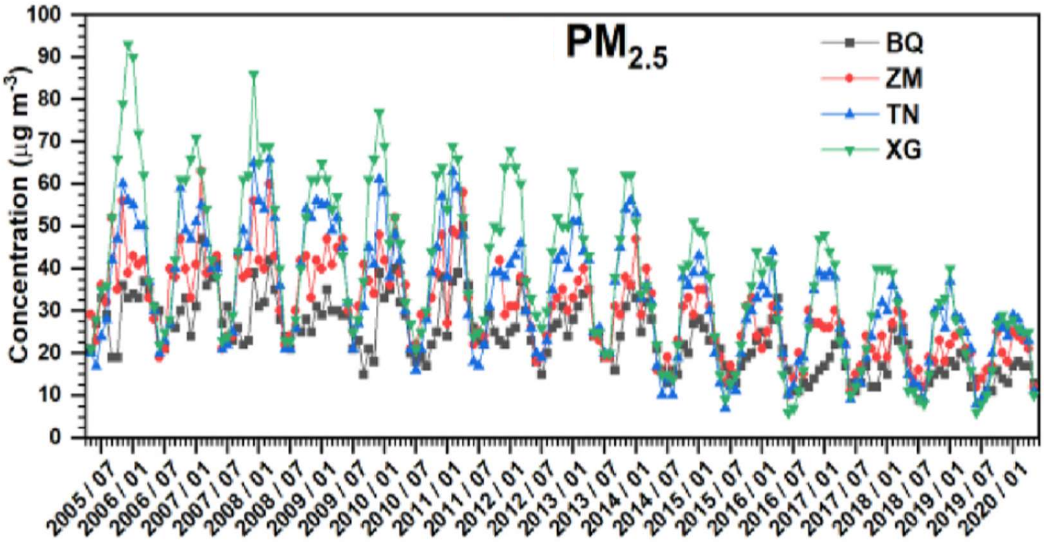


**Fig. 1.** Long-term trends of PM2.5 and gaseous pollutants monitored at the Banqiao, Zhongming, Tainan, and Xiaogang stations. (Chuang et al., 2021)

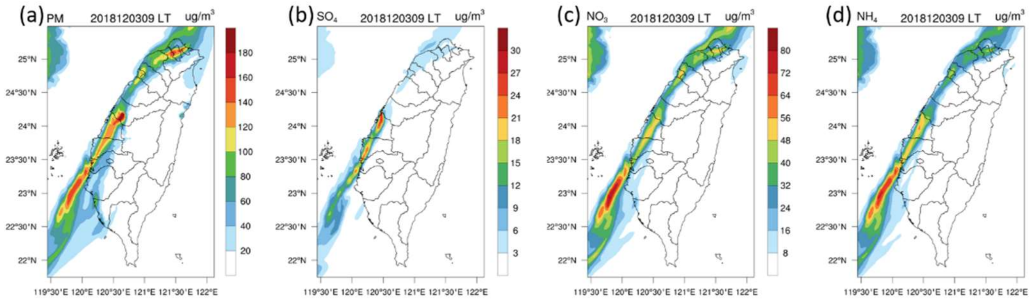


**Fig. 2.** Surface layer concentration in Taiwan of CTL run. Select a representative distribution. (a) the total PM concentration. (b) sulfate (c) nitrate (d) ammonium formation in PM.

PM and its secondary inorganic formations show similar spatial patterns, with the highest concentrations occurring in the western region of Taiwan. This area is characterized by flat terrain, high population density, and intense industrial activities, making it a major residential and industrial agglomeration zone.

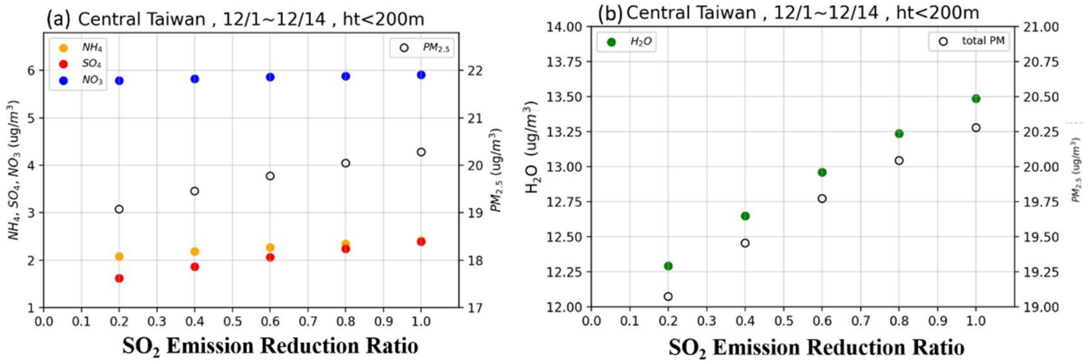


**Fig. 3.** CTL and EXP2 run ($SO_2$ emission adjustment experiments). (a) sulfate, nitrate, ammonium formation, and total $PM_{2.5}$ surface layer average concentration in Central Taiwan. (b) liquid water formation and total $PM_{2.5}$ surface layer average concentration in Central Taiwan.

As $SO_2$ emission reduces, sulfate has the most significant decrease. To maintain the pH balance, ammonium also decreases. The slight change in nitrate is attributed to the decline in sulfate and ammonium, which leads to a reduction in water in PM. As a result, the amount of dissolved nitric acid also decreases.

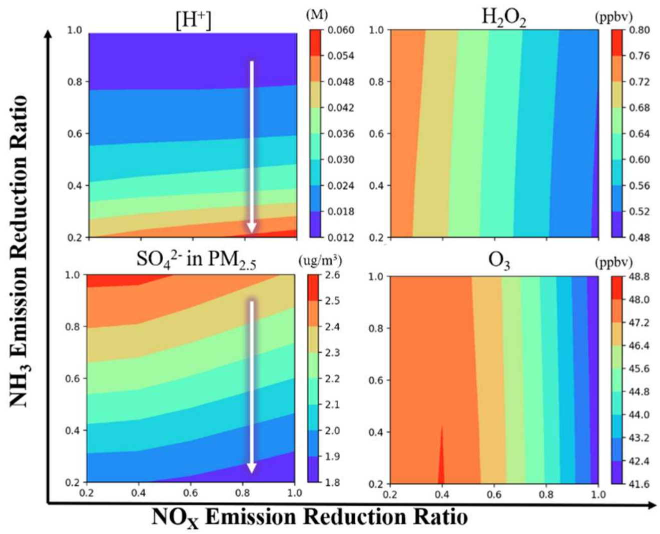


**Fig. 4.** CTL run and EXP3 run ($NO_X$ and $NH_3$ emission reduction separately or simultaneously experiments). Surface layer average concentration of proton in $PM_{2.5}$, sulfate in $PM_{2.5}$, gas phase hydrogen peroxide and gas phase ozone in Central Taiwan. The photon and sulfate in $PM_{2.5}$ decrease as the $NH_3$ emission reduces. But the hydrogen peroxide and ozone do not have the same pattern.

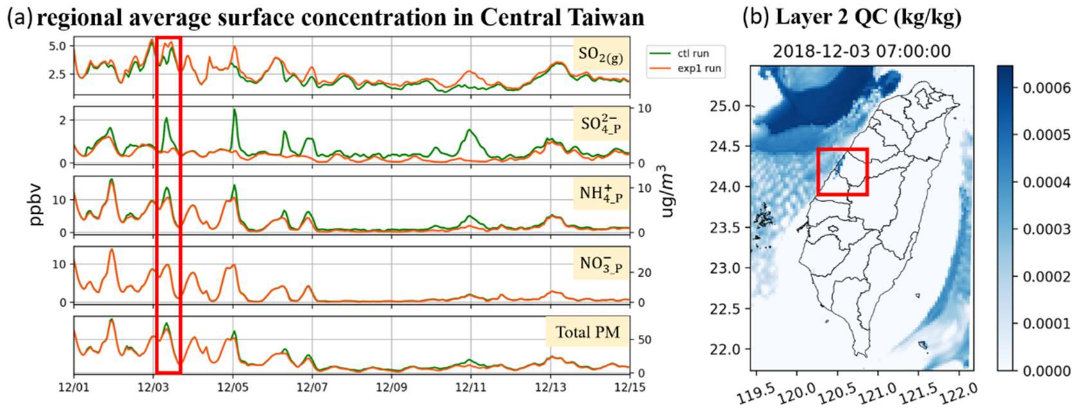


**Fig. 5.** We select a grid point with both strong aqueous phase chemistry and high cloud water. Specifically, we chose a grid point located on the second layer (approximately 64.54 meters above sea level) in the model, situated on the Taichung coast (120.5053E, 24.203N) at 7:00 am local time on December 3, 2018.