**Table S11.** WRF-CMAQ modelling system configurations

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| --- | --- | --- | --- |
| Model | Parameter | Configuration schemes | |
| WRF | Horizontal resolution | | 36km, 181 (column) × 136 (row) |
| Vertical resolution | | 47 sigma levels from surface to tropopause |
| Simulation cases | | All fixed with the meteorology in 2020 (Base-year) |
| Simulation period | | The whole year with one-month spin-up |
| IC and BC | | Final analysis data from NCEP |
| Shortwave radiation | | New Goddard scheme1 |
| Longwave radiation | | RRTM scheme2 |
| Surface layer | | Pleim–Xiu scheme3 |
| Planetary boundary layer | | ACM2 scheme4 |
| Cumulus | | Kain–Fritsch scheme5 |
| Cloud microphysics | | WSM6 scheme |
| Nudging | | Analysis nudging, observational nudging, soil nudging were conducted |
| CMAQ | Horizontal resolution | | 36km, 172 (column) × 127 (row) |
| Vertical resolution | | 28 sigma levels from surface to tropopause: 1.000, 0.9975, 0.995, 0.992, 0.988, 0.984, 0.980, 0.975, 0.970, 0.963, 0.956, 0.938, 0.916, 0.893, 0.868, 0.839, 0.808, 0.777, 0.744, 0.7020, 0.6480, 0.582, 0.500, 0.400, 0.300, 0.200, 0.120, 0.052, 0.000. |
| Simulation cases | | Historical: 2020 (Base-year)  Future: Five groups of future scenarios, with 5-year step (i.e., 2025, 2030, 2035, 2040, 2045, 2050, 2055, 2060) |
| Simulation period | | The whole year with one-month spin-up |
| IC and BC | | Dynamic GEOS-Chem global simulation outputs |
| Gas-phase mechanism | | CB05 |
| Aqueous-phase mechanism | | RADM |
| Aerosol module | | AERO6 |
| Cloud module | | ACM\_AE6 ACM cloud processor |
| Photolytic rate | | In-line calculation |
| Anthropogenic emissions | | Historical: MEIC for China; MIX for other Asian countries  Future: DPEC for China; CMIP6 for other Asian countries |
| Biogenic emissions | | MEGANv2.16 |
| Open biomass burning | | GFED47 |
| Dust | | In-line calculation |
| Lightning | | Not included |