

Multiscale Applications of Two Online-Coupled Meteorology-Chemistry Models during Recent Field Campaigns in Australia, Part I: Model Description and WRF/Chem-ROMS Evaluation Using Surface and Satellite Data and Sensitivity to Spatial Grid Resolutions

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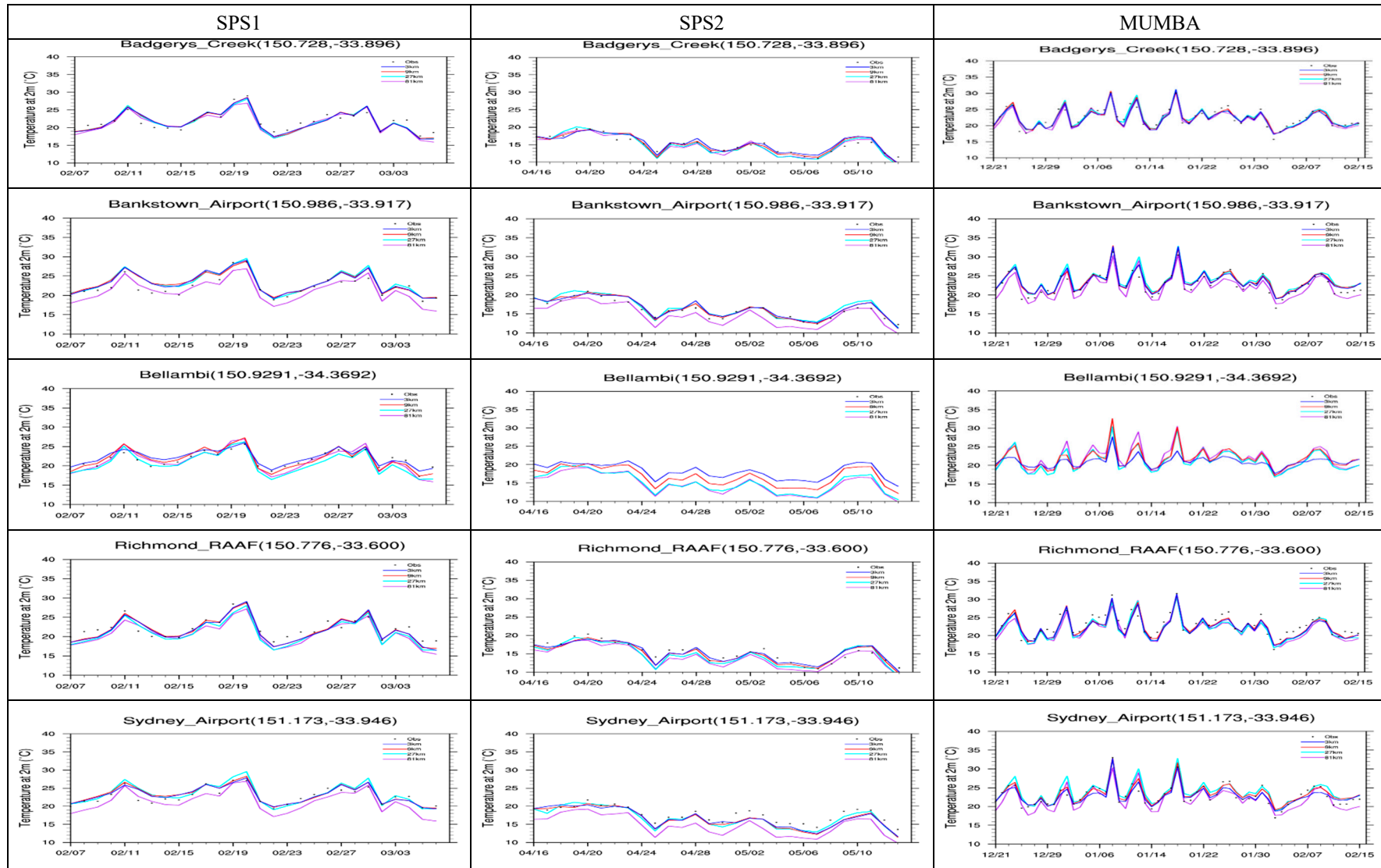


Figure S1. Observed and simulated temporal profiles of temperature at 2-m at selected sites during SPS1, SPS2, and MUMBA. All simulation results are based on WRF/Chem-ROMS. No observations are available at Bellambi during SPS2 and MUMBA.

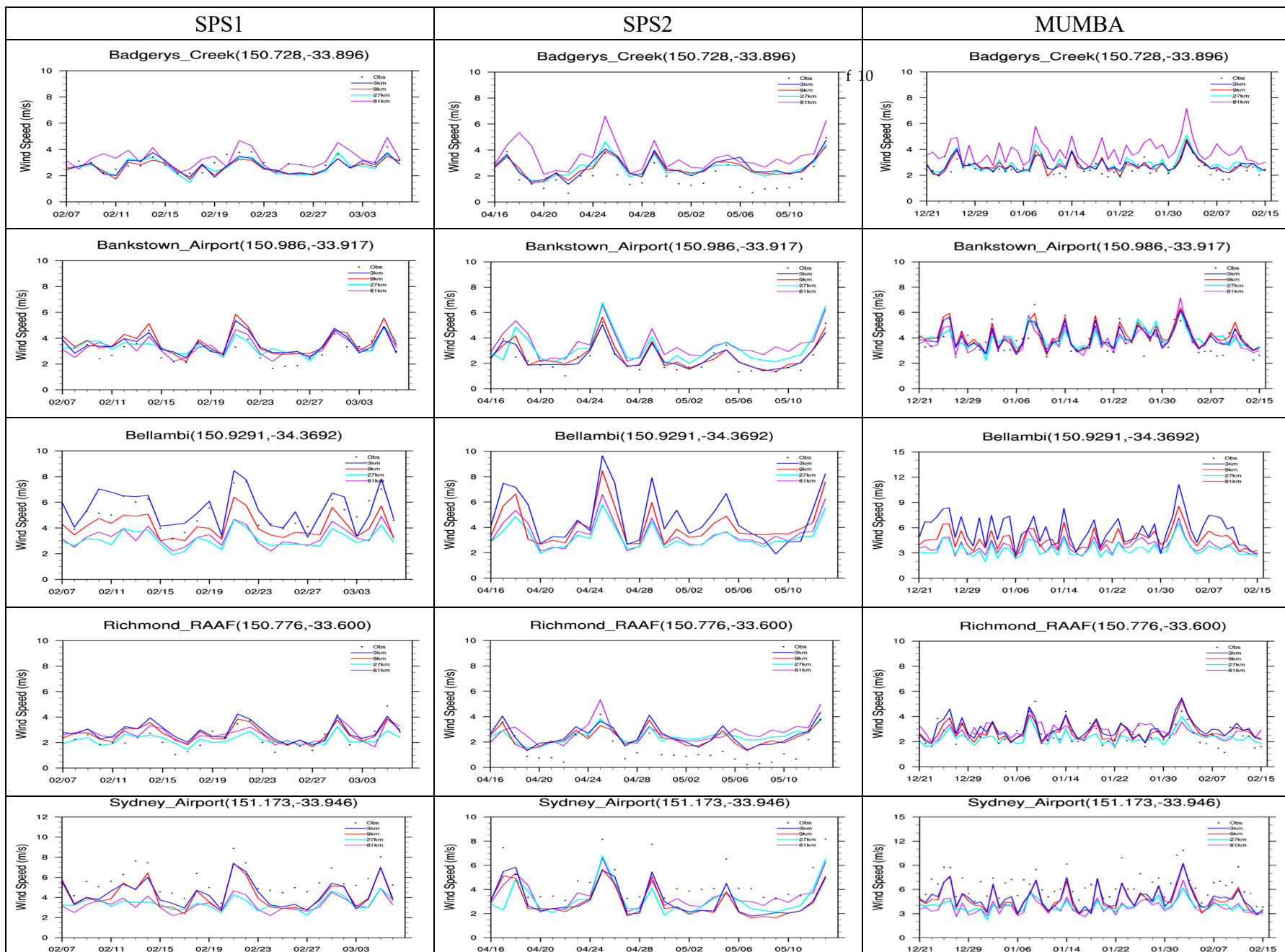


Figure S2. Observed and simulated temporal profiles of wind speed at 10-m at selected sites during SPS1, SPS2, and MUMBA. All simulation results are based on WRF/ChemROMS. No observations are available at Bellambi during SPS2 and MUMBA.

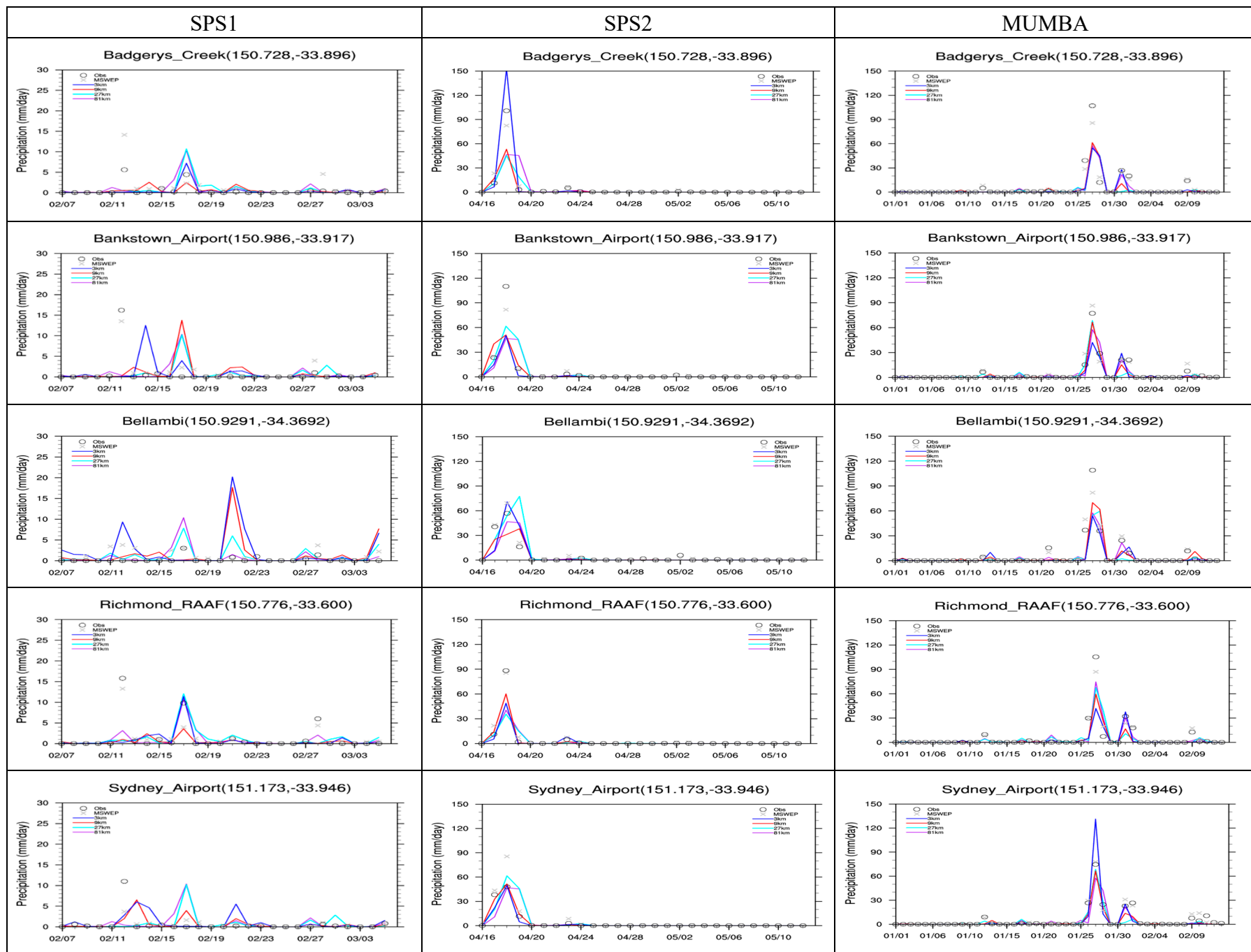


Figure S3. Observed and simulated temporal profiles of precipitation at selected sites during SPS1, SPS2, and MUMBA. All simulation results are based on WRF/Chem-ROMS.

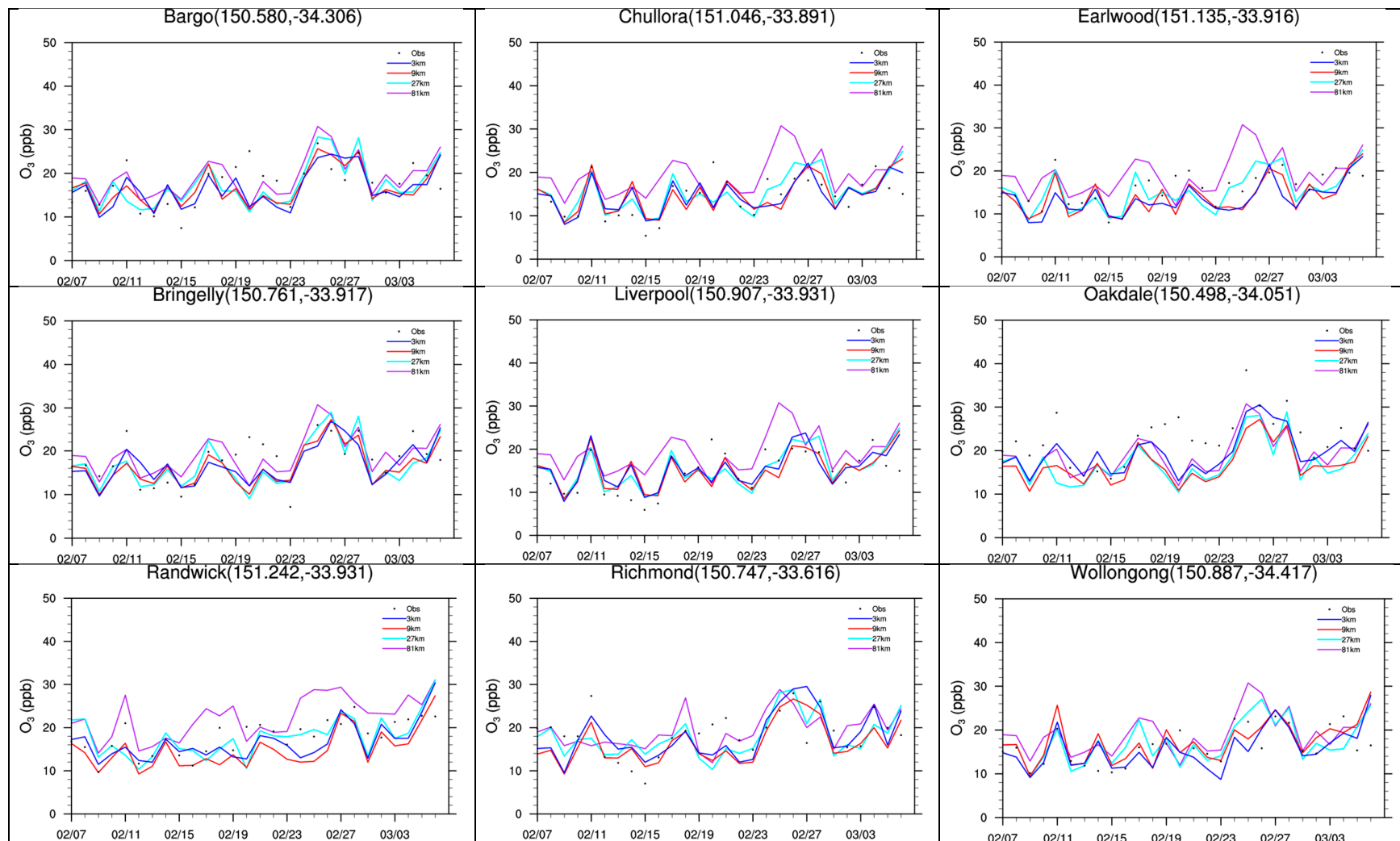


Figure S4. Observed and simulated temporal profiles of O₃ concentrations at selected sites during SPS1. All simulation results are based on WRF/Chem-ROMS.

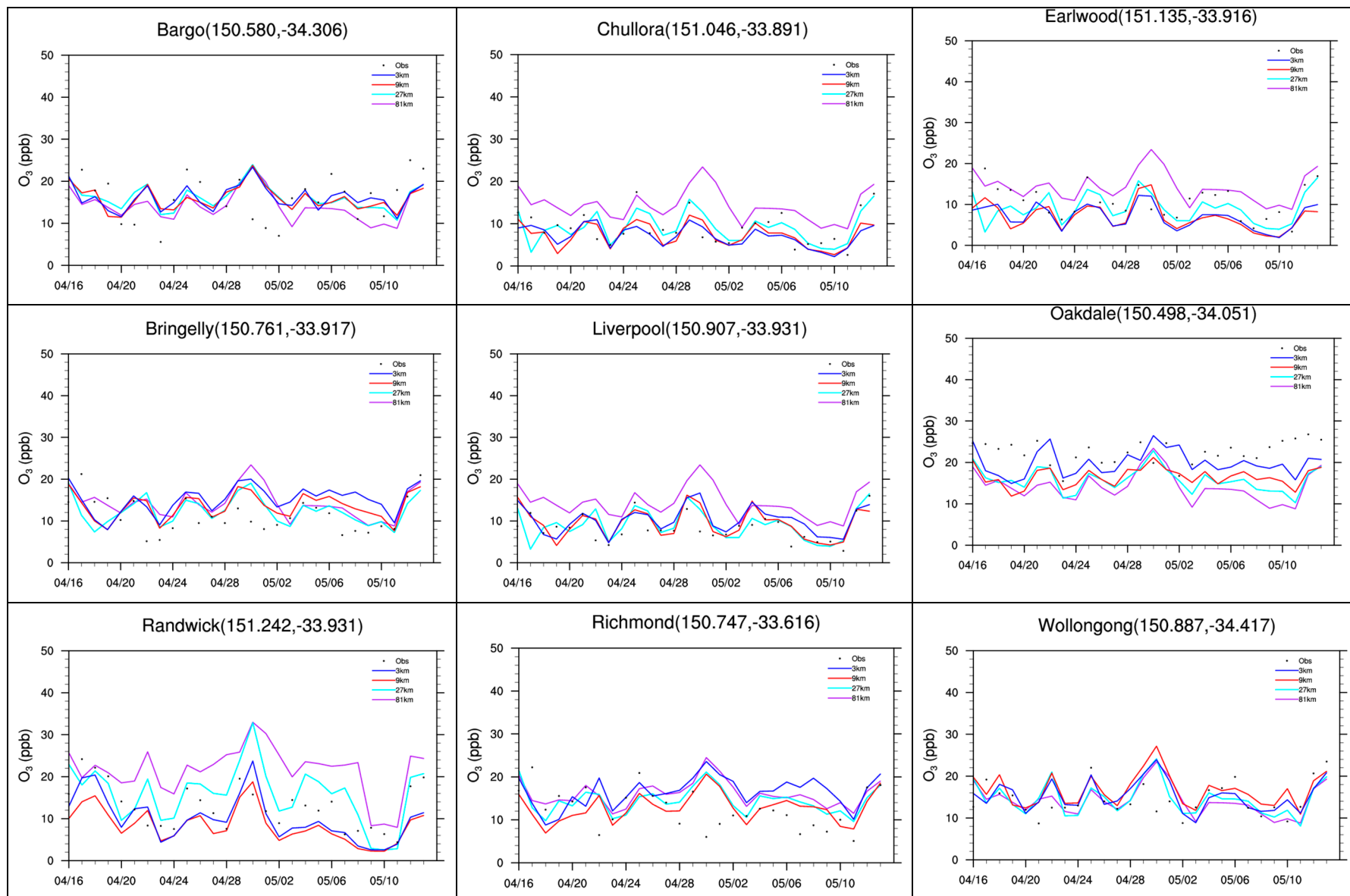


Figure S5. Observed and simulated temporal profiles of O₃ concentrations at selected sites during SPS2. All simulation results are based on WRF/Chem-ROMS.

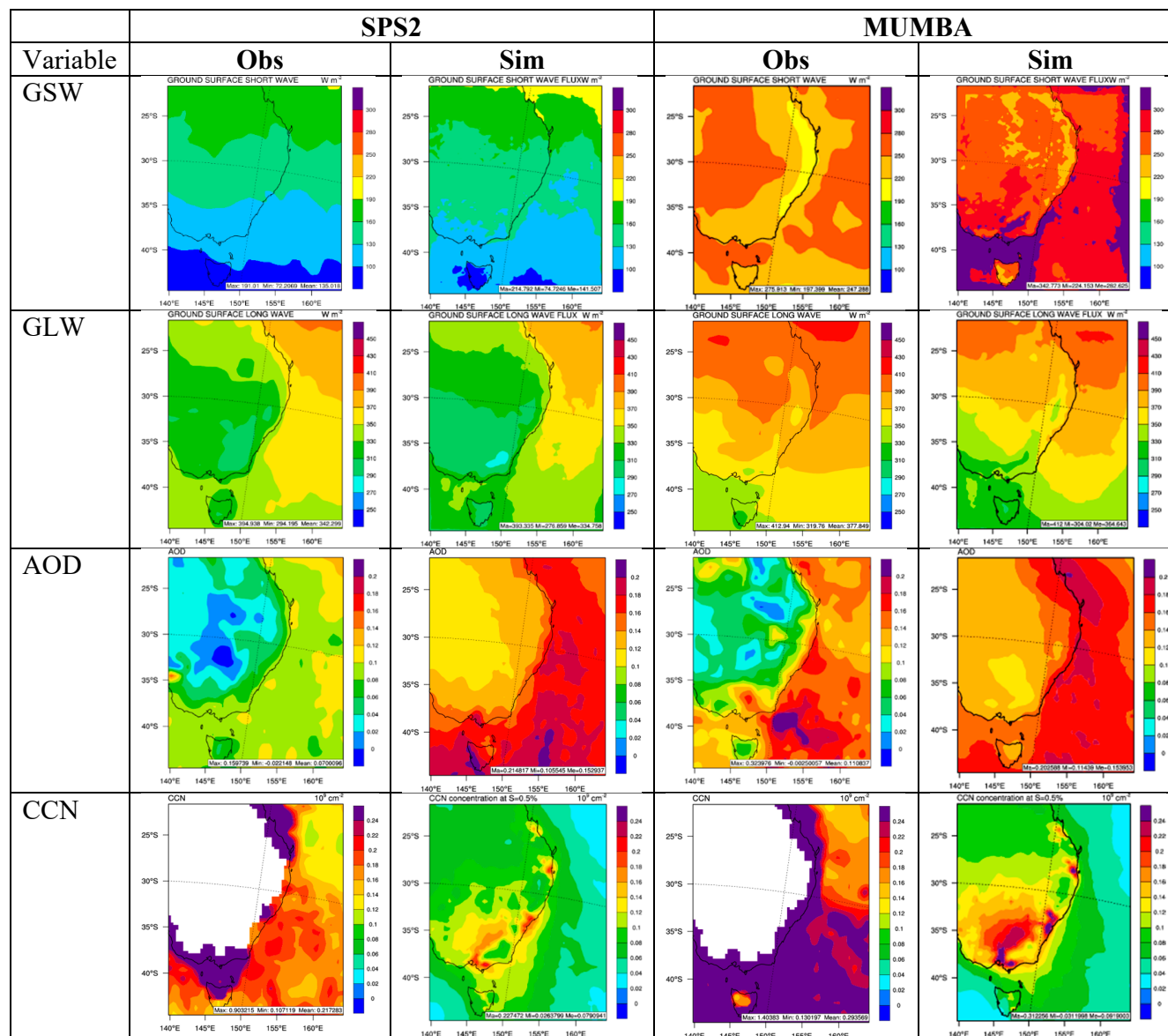


Figure S6. Observed and simulated radiation and optical variables and CCN over southeastern Australia (d02) during SPS2 and MUMBA. The simulation results are from WRF/Chem-ROMS.

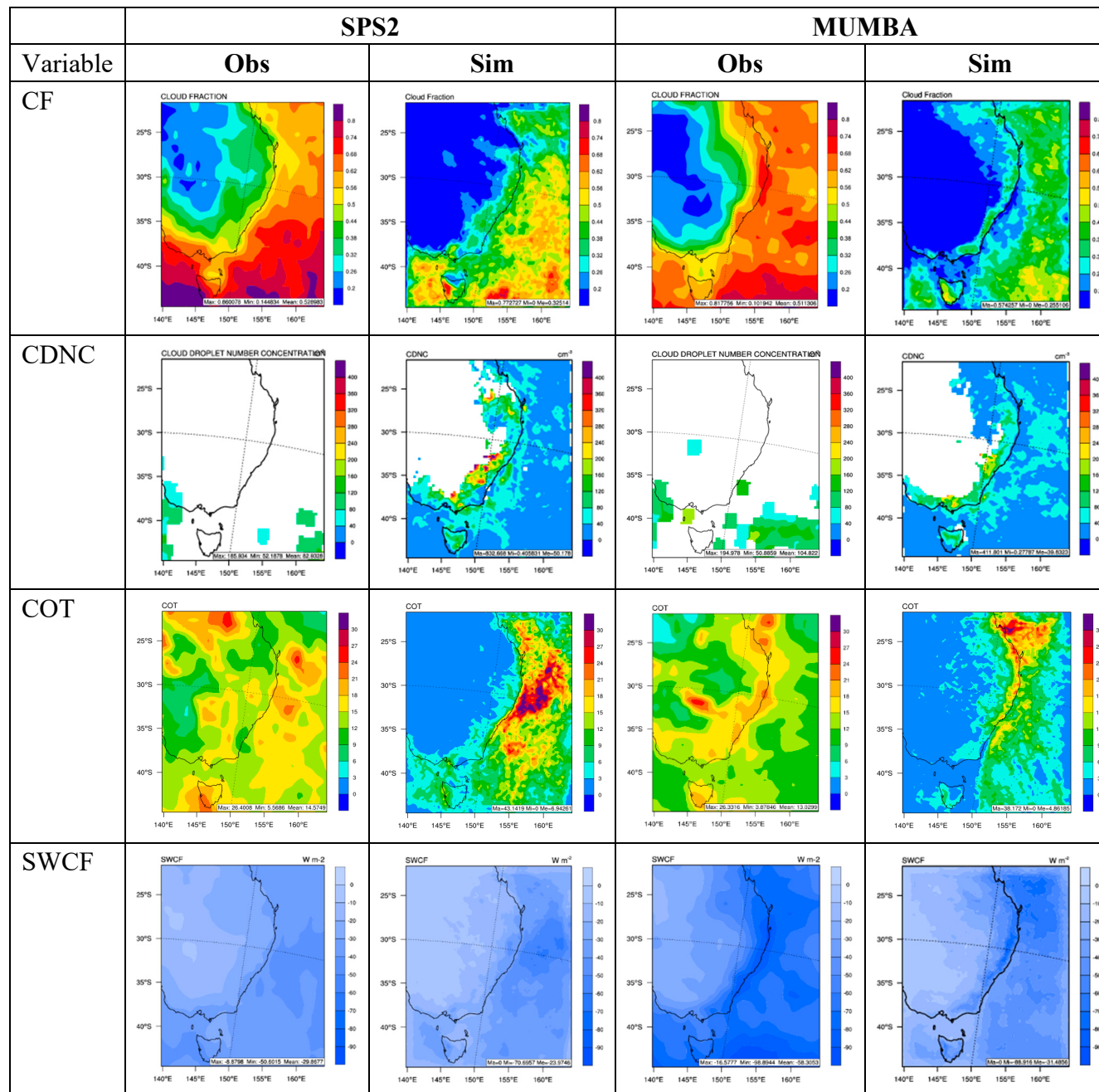


Figure S7. Observed and simulated cloud variables over southeastern Australia (d02) during SPS2 and MUMBA. The simulation results are from WRF/Chem-ROMS.

Table S1. Statistics of O₃ for WRF/Chem-ROMS v3.7.1 simulations (81-km, 27-km, 9-km, and 3-km) over 9 individual sites of 3-km domain.

(a) SPS1

| Sites | Mean Obs | σ Obs | Mean Sim | | | | σ Sim | | | | R | | | | NMB | | | | NME | | | |
|------------|----------|--------------|----------|------|------|------|--------------|------|------|------|------|------|------|------|-------|-------|-------|-------|------|------|------|------|
| | | | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 |
| Bargo | 17.8 | 11.6 | 19.7 | 17.8 | 17.3 | 17.1 | 11.5 | 9.8 | 10.3 | 10.7 | 0.78 | 0.75 | 0.75 | 0.75 | 10.7 | 0.1 | -3.0 | -4.1 | 36.0 | 34.2 | 34.7 | 35.1 |
| Bringelly | 18.1 | 11.7 | 19.7 | 17.4 | 16.9 | 17.4 | 11.4 | 12.4 | 10.8 | 10.7 | 0.79 | 0.78 | 0.76 | 0.73 | 9.1 | -3.8 | -6.4 | -3.5 | 33.8 | 34.2 | 33.5 | 34.9 |
| Chullora | 14.3 | 10.8 | 19.7 | 15.9 | 15.2 | 14.9 | 11.5 | 12.0 | 10.9 | 10.4 | 0.68 | 0.74 | 0.70 | 0.71 | 37.3 | 10.9 | 6.4 | 3.9 | 57.2 | 42.9 | 42.8 | 41.0 |
| Earlwood | 16.0 | 9.6 | 19.5 | 15.7 | 14.3 | 13.7 | 11.5 | 11.9 | 10.0 | 9.0 | 0.68 | 0.74 | 0.71 | 0.72 | 22.1 | -1.6 | -10.8 | -14.1 | 45.0 | 37.4 | 35.0 | 34.5 |
| Liverpool | 14.7 | 11.6 | 19.6 | 15.8 | 15.6 | 16.0 | 11.5 | 12.0 | 11.4 | 11.6 | 0.74 | 0.78 | 0.73 | 0.72 | 33.2 | 7.6 | 5.9 | 8.3 | 52.4 | 39.8 | 41.8 | 42.6 |
| Oakdale | 22.6 | 9.9 | 19.5 | 17.7 | 17.3 | 19.9 | 11.5 | 10.0 | 10.3 | 9.4 | 0.73 | 0.73 | 0.76 | 0.74 | -13.7 | -22.0 | -23.6 | -12.1 | 30.9 | 30.9 | 31.5 | 25.1 |
| Randwick | 18.1 | 9.0 | 22.9 | 18.1 | 15.2 | 16.9 | 9.6 | 8.4 | 9.2 | 9.1 | 0.61 | 0.62 | 0.70 | 0.69 | 26.6 | 0.1 | -15.8 | -6.7 | 37.7 | 32.3 | 32.4 | 29.9 |
| Richmond | 18.4 | 12.2 | 19.7 | 18.3 | 16.8 | 18.3 | 10.2 | 11.3 | 11.8 | 10.8 | 0.74 | 0.76 | 0.78 | 0.72 | 6.7 | -1.0 | -9.0 | -0.8 | 35.7 | 34.1 | 34.5 | 36.4 |
| Wollongong | 16.2 | 9.6 | 19.5 | 17.4 | 17.6 | 15.9 | 11.5 | 11.2 | 9.2 | 8.9 | 0.69 | 0.69 | 0.66 | 0.62 | 20.0 | 7.5 | 8.8 | -2.2 | 43.8 | 38.2 | 37.1 | 38.7 |

(b) SPS2

| Sites | Mean Obs | σ Obs | Mean Sim | | | | σ Sim | | | | R | | | | NMB | | | | NME | | | |
|------------|----------|--------------|----------|------|------|------|--------------|-----|-----|------|------|------|------|------|-------|-------|-------|-------|------|------|------|------|
| | | | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 |
| Bargo | 17.5 | 8.7 | 14.6 | 16.6 | 16.2 | 16.8 | 8.3 | 6.3 | 6.3 | 6.2 | 0.54 | 0.48 | 0.46 | 0.48 | -16.4 | -5.2 | -7.4 | -3.9 | 39.3 | 37.1 | 38.3 | 36.0 |
| Bringelly | 11.4 | 10.0 | 14.4 | 12.7 | 13.7 | 15.2 | 8.4 | 9.1 | 8.1 | 7.9 | 0.71 | 0.74 | 0.70 | 0.59 | 25.9 | 11.1 | 20.1 | 33.5 | 53.6 | 49.2 | 53.4 | 62.9 |
| Chullora | 9.0 | 8.9 | 14.4 | 9.3 | 7.7 | 7.4 | 8.4 | 8.8 | 9.1 | 9.2 | 0.72 | 0.71 | 0.69 | 0.70 | 59.4 | 3.2 | -14.9 | -17.8 | 71.7 | 52.3 | 55.6 | 56.0 |
| Earlwood | 10.8 | 9.1 | 14.3 | 9.2 | 7.2 | 7.3 | 8.4 | 8.8 | 8.7 | 8.7 | 0.69 | 0.68 | 0.67 | 0.70 | 32.8 | -14.3 | -33.3 | -32.8 | 54.5 | 50.1 | 56.0 | 52.9 |
| Liverpool | 8.3 | 8.9 | 14.4 | 9.3 | 9.6 | 10.4 | 8.4 | 8.8 | 9.3 | 8.2 | 0.70 | 0.67 | 0.67 | 0.67 | 73.2 | 11.7 | 15.8 | 25.2 | 86.4 | 61.8 | 62.7 | 65.4 |
| Oakdale | 22.4 | 4.9 | 14.4 | 16.0 | 16.7 | 20.0 | 8.4 | 6.9 | 6.7 | 5.6 | 0.44 | 0.50 | 0.42 | 0.31 | -36.0 | -28.6 | -25.8 | -11.0 | 41.8 | 33.8 | 31.4 | 23.5 |
| Randwick | 13.0 | 10.0 | 21.7 | 16.0 | 8.6 | 10.2 | 7.2 | 8.8 | 8.9 | 10.1 | 0.38 | 0.48 | 0.70 | 0.70 | 66.6 | 22.9 | -33.5 | -21.2 | 78.5 | 57.3 | 49.9 | 46.3 |
| Richmond | 12.7 | 10.4 | 16.2 | 14.7 | 13.0 | 16.5 | 7.5 | 8.3 | 8.5 | 7.4 | 0.72 | 0.76 | 0.71 | 0.52 | 27.7 | 15.8 | 2.9 | 30.3 | 51.1 | 43.2 | 46.9 | 61.7 |
| Wollongong | 14.4 | 9.4 | 14.4 | 14.8 | 16.7 | 15.3 | 8.4 | 7.9 | 7.1 | 6.8 | 0.52 | 0.53 | 0.42 | 0.44 | -0.1 | 2.7 | 16.4 | 6.4 | 49.0 | 46.6 | 50.0 | 48.4 |

(c) MUMBA

| Sites | Mean Obs | σ Obs | Mean Sim | | | | σ Sim | | | | R | | | | NMB | | | | NME | | | |
|------------|----------|--------------|----------|------|------|------|--------------|------|------|------|------|------|------|------|-------|-------|-------|-------|------|------|------|------|
| | | | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 |
| Bargo | 21.5 | 15.1 | 21.1 | 20.1 | 19.2 | 18.2 | 12.0 | 12.0 | 13.6 | 13.9 | 0.74 | 0.75 | 0.80 | 0.81 | -2.0 | -6.6 | -10.8 | -15.6 | 36.5 | 34.1 | 31.4 | 31.8 |
| Bringelly | 18.9 | 14.8 | 20.8 | 19.2 | 17.8 | 17.5 | 11.7 | 13.7 | 13.2 | 13.4 | 0.71 | 0.71 | 0.70 | 0.74 | 10.0 | 1.5 | -5.8 | -7.6 | 43.1 | 42.4 | 39.4 | 37.6 |
| Chullora | 15.6 | 10.5 | 21.1 | 17.6 | 15.9 | 15.3 | 12.0 | 12.9 | 11.0 | 10.2 | 0.57 | 0.63 | 0.63 | 0.59 | 35.2 | 12.4 | 1.7 | -1.9 | 60.1 | 49.4 | 43.0 | 43.2 |
| Earlwood | 17.1 | 9.0 | 20.9 | 17.4 | 14.9 | 13.7 | 12.0 | 12.9 | 9.4 | 9.0 | 0.48 | 0.56 | 0.59 | 0.55 | 22.8 | 2.2 | -12.9 | -19.5 | 53.1 | 46.4 | 37.6 | 39.4 |
| Liverpool | 17.0 | 13.5 | 21.1 | 17.7 | 16.9 | 17.0 | 12.0 | 13.0 | 12.7 | 13.1 | 0.64 | 0.67 | 0.67 | 0.67 | 24.0 | 3.6 | -1.0 | -0.4 | 54.3 | 45.9 | 44.2 | 44.3 |
| Oakdale | 23.9 | 13.2 | 21.0 | 20.1 | 19.3 | 21.2 | 11.8 | 12.0 | 12.5 | 12.0 | 0.68 | 0.66 | 0.73 | 0.73 | -12.1 | -15.9 | -19.5 | -11.5 | 32.9 | 33.6 | 32.4 | 28.9 |
| Randwick | 18.9 | 7.3 | 22.7 | 18.2 | 15.9 | 16.0 | 11.9 | 9.4 | 8.7 | 8.6 | 0.54 | 0.47 | 0.54 | 0.46 | 20.2 | -3.7 | -15.7 | -15.5 | 41.1 | 35.1 | 33.9 | 35.2 |
| Richmond | 20.0 | 12.3 | 20.5 | 20.0 | 17.6 | 18.5 | 10.3 | 12.5 | 13.1 | 12.2 | 0.65 | 0.70 | 0.72 | 0.71 | 2.4 | 0.2 | -11.7 | -7.2 | 36.8 | 36.3 | 36.3 | 35.1 |
| Wollongong | 15.0 | 7.9 | 20.8 | 18.6 | 17.6 | 15.2 | 11.7 | 12.1 | 9.3 | 8.7 | 0.48 | 0.50 | 0.51 | 0.52 | 38.6 | 24.0 | 17.0 | 1.4 | 62.2 | 53.7 | 44.8 | 41.8 |

Table S2. Statistics of PM_{2.5} for WRF/Chem-ROMS v3.7.1 simulations (81-km, 27-km, 9-km, and 3-km) over 5 individual sites of 3-km domain.

(a) SPS1

| Sites | Mean Obs | σ Obs | Mean Sim | | | | σ Sim | | | | R | | | | NMB | | | | NME | | | |
|------------|----------|--------------|----------|------|------|------|--------------|------|------|------|-------|-------|------|------|-------|-------|-------|-------|------|------|------|------|
| | | | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 |
| Chullora | 6.75 | 4.51 | 3.52 | 4.32 | 4.47 | 4.84 | 0.99 | 1.52 | 1.92 | 2.52 | 0.02 | 0.15 | 0.27 | 0.26 | -47.8 | -36.0 | -33.7 | -28.2 | 56.8 | 51.1 | 50.0 | 50.3 |
| Earlwood | 5.61 | 3.56 | 3.52 | 4.33 | 4.54 | 4.40 | 0.99 | 1.54 | 1.97 | 1.67 | -0.02 | 0.15 | 0.34 | 0.35 | -37.2 | -22.7 | -19.1 | -21.6 | 54.4 | 50.9 | 48.3 | 47.9 |
| Liverpool | 5.26 | 3.65 | 3.53 | 4.34 | 4.47 | 4.34 | 0.99 | 1.53 | 1.73 | 2.07 | 0.04 | 0.19 | 0.37 | 0.28 | -32.8 | -17.6 | -15.1 | -17.5 | 55.1 | 52.7 | 48.7 | 52.3 |
| Richmond | 5.16 | 3.37 | 2.96 | 3.39 | 3.74 | 3.60 | 0.87 | 1.07 | 1.50 | 1.34 | -0.03 | -0.03 | 0.10 | 0.06 | -42.6 | -34.2 | -27.5 | -30.2 | 59.1 | 57.1 | 55.9 | 57.5 |
| Wollongong | 5.77 | 3.73 | 3.53 | 3.85 | 3.76 | 4.57 | 0.99 | 1.33 | 1.28 | 2.90 | -0.08 | 0.11 | 0.21 | 0.18 | -38.8 | -33.3 | -34.8 | -20.8 | 54.3 | 52.8 | 51.7 | 53.2 |

(b) SPS2

| Sites | Mean Obs | σ Obs | Mean Sim | | | | σ Sim | | | | R | | | | NMB | | | | NME | | | |
|------------|----------|--------------|----------|------|------|------|--------------|------|------|------|------|------|------|------|-------|------|-------|-------|------|-------|-------|-------|
| | | | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 |
| Chullora | 6.52 | 4.94 | 5.49 | 11.2 | 18.8 | 21.5 | 3.11 | 11.0 | 20.6 | 25.3 | 0.41 | 0.46 | 0.45 | 0.44 | -15.8 | 71.4 | 187.9 | 229.0 | 51.2 | 95.8 | 200.2 | 239.4 |
| Earlwood | 6.42 | 4.90 | 5.52 | 11.3 | 21.4 | 25.0 | 3.12 | 10.9 | 23.9 | 31.5 | 0.37 | 0.45 | 0.49 | 0.44 | -14.1 | 75.2 | 232.6 | 288.8 | 54.9 | 101.0 | 242.9 | 297.8 |
| Liverpool | 11.2 | 7.90 | 6.22 | 16.3 | 16.5 | 18.1 | 4.22 | 16.9 | 16.3 | 18.0 | 0.42 | 0.47 | 0.47 | 0.41 | -44.6 | 45.7 | 47.3 | 61.1 | 57.9 | 85.4 | 83.0 | 92.1 |
| Richmond | 4.27 | 3.11 | 3.92 | 4.69 | 5.40 | 5.17 | 1.43 | 2.00 | 2.77 | 2.88 | 0.03 | 0.09 | 0.12 | 0.11 | -8.4 | 9.6 | 26.2 | 20.9 | 60.8 | 65.3 | 74.2 | 71.6 |
| Wollongong | 4.31 | 3.22 | 5.52 | 5.25 | 5.00 | 6.87 | 3.12 | 2.77 | 2.34 | 4.68 | 0.10 | 0.15 | 0.09 | 0.14 | 28.0 | 21.8 | 16.0 | 59.4 | 76.9 | 71.3 | 67.7 | 92.3 |

(c) MUMBA

| Sites | Mean Obs | σ Obs | Mean Sim | | | | σ Sim | | | | R | | | | NMB | | | | NME | | | |
|------------|----------|--------------|----------|------|------|------|--------------|------|------|------|-------|------|------|------|-------|-------|-------|-------|------|------|------|------|
| | | | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 | D01 | D02 | D03 | D04 |
| Chullora | 7.99 | 4.41 | 3.38 | 4.10 | 4.31 | 4.42 | 0.89 | 1.37 | 1.92 | 1.96 | 0.02 | 0.25 | 0.37 | 0.37 | -57.7 | -48.7 | -46.1 | -44.7 | 61.8 | 55.2 | 53.4 | 52.3 |
| Earlwood | 6.97 | 4.27 | 3.39 | 4.09 | 4.19 | 4.28 | 0.89 | 1.37 | 1.74 | 1.63 | -0.05 | 0.11 | 0.27 | 0.30 | -51.4 | -41.3 | -39.8 | -38.6 | 59.5 | 54.3 | 52.8 | 51.2 |
| Liverpool | 7.76 | 4.97 | 3.43 | 4.09 | 4.36 | 4.42 | 0.91 | 1.37 | 1.85 | 2.34 | -0.07 | 0.05 | 0.17 | 0.10 | -55.8 | -47.3 | -43.9 | -43.1 | 63.5 | 59.5 | 57.6 | 59.6 |
| Richmond | 7.10 | 4.45 | 2.78 | 3.20 | 3.36 | 3.39 | 0.78 | 1.00 | 1.29 | 1.42 | -0.10 | 0.05 | 0.15 | 0.16 | -60.8 | -54.9 | -52.7 | -52.3 | 66.8 | 62.7 | 60.9 | 61.0 |
| Wollongong | 7.75 | 5.14 | 3.37 | 3.80 | 3.78 | 4.66 | 0.88 | 1.20 | 1.30 | 2.61 | -0.05 | 0.04 | 0.20 | 0.18 | -56.4 | -50.9 | -51.2 | -39.8 | 63.0 | 60.1 | 59.3 | 56.1 |