

Supporting Information for

Effects of cloud microphysics on the universal performance of neural network radiation scheme

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Introduction

This supporting information represents Table S1–S2 for the information of cloud microphysics schemes and computation time for ideal case simulation, respectively. Supplementary time series for real and ideal case simulations are given in Figs. S1–S4. The neural network (NN) trainings of the RRTMG-K radiation process for real cases were based on the period of 2009–2019, while prognostic evaluation using the radiation emulator was performed for the year 2020. The emulator was developed under the influence of the WDM7 scheme (Bae et al. 2019). The emulator for land and July developed in the real case simulation was applied to the 2D idealized squalline experiment.

Table S1. Experiments for microphysics parameterizations with the use of radiation emulator. Note that the emulator was developed under the influence of the WDM7 scheme. Q and N are mixing rate and number concentration for hydrometeors. The prediction of Q only is called as “single moment scheme”, whereas both prediction of Q and N is “double moment scheme”. P3 is the most advanced scheme that predicts ice properties for snow, graupel, and hail.

mp_physics	Descriptions	References
MP26 (WDM7)	6-class Q, 3-class N	Bae et al. (2019)
MP02 (Lin)	5-class Q	Lin et al. (1983)
MP05 (Eta)	3-class Q	Skamarock et al. (2019)
MP06 (WSM6)	5-class Q	Hong and Lim (2006)
MP07 (Goddard)	5-class Q	Tao et al. (1989)
MP08 (Thompson)	5-class Q, 2-class N	Thompson et al. (2008)
MP09 (Milbrandt)	6-class Q, 6-class N	Milbrandt and Yau (2005)
MP10 (Morrison)	5-class Q, 4-class N	Morrison et al. (2009)
MP11 (CAM5.1)	5-class Q, 4-class N	Neale et al. (2012)
MP13 (SBU-YLin)	4-class Q	Lin and Colle (2011)
MP16 (WDM6)	5-class Q, 3-class N	Lim and Hong (2010)
MP17 (NSSL)	6-class Q, 6-class N	Mansell et al (2010)
MP19 (NSSL-1m)	6-class Q	Mansell et al (2010)
MP28 (Thompson_A)	5-class Q, 4-class N	Thompson and Eidhammer (2014)
MP50 (P3)	3-class Q, 2-class N, ice properties	Morrison and Milbrandt (2015)

Table S2. Statistics of computation time for ideal case simulations using 15 microphysics schemes under the serial compilation using the Intel Xeon E5-2690v3 central processing unit (CPU). The control run and the emulator were given before and after arrows.

mp_physics	Total (s)	Radiation (s)	Total Reduction (%)
MP26 (WDM7)	3774.45	577.40 → 1597.15	84.70 → 57.69
MP02 (Lin)	3664.64	373.46 → 1365.36	89.81 → 62.74
MP05 (Eta)	3391.31	238.84 → 1364.49	92.96 → 59.77
MP06 (WSM6)	3502.70	358.73 → 1390.87	89.76 → 60.29
MP07 (Goddard)	3636.47	312.71 → 1423.06	91.40 → 60.87
MP08 (Thompson)	3535.23	392.63 → 1519.41	88.89 → 57.02
MP09 (Milbrandt)	3575.42	353.26 → 1443.90	90.12 → 59.62
MP10 (Morrison)	3598.54	439.25 → 1483.01	87.79 → 58.79
MP11 (CAM5.1)	4037.56	845.58 → 2327.07	79.06 → 42.36
MP13 (SBU-YLIN)	3398.31	280.15 → 1454.20	91.76 → 57.21
MP16 (WDM6)	3620.09	571.57 → 1630.51	84.21 → 54.96
MP17 (NSSL)	3599.78	399.74 → 1480.28	88.90 → 58.88
MP19 (NSSL-1mom)	3472.67	285.09 → 1153.68	91.79 → 66.78
MP28 (Thompson_A)	3591.78	424.03 → 1558.39	88.19 → 56.61
MP50 (P3)	3324.00	297.18 → 1289.92	91.06 → 61.19

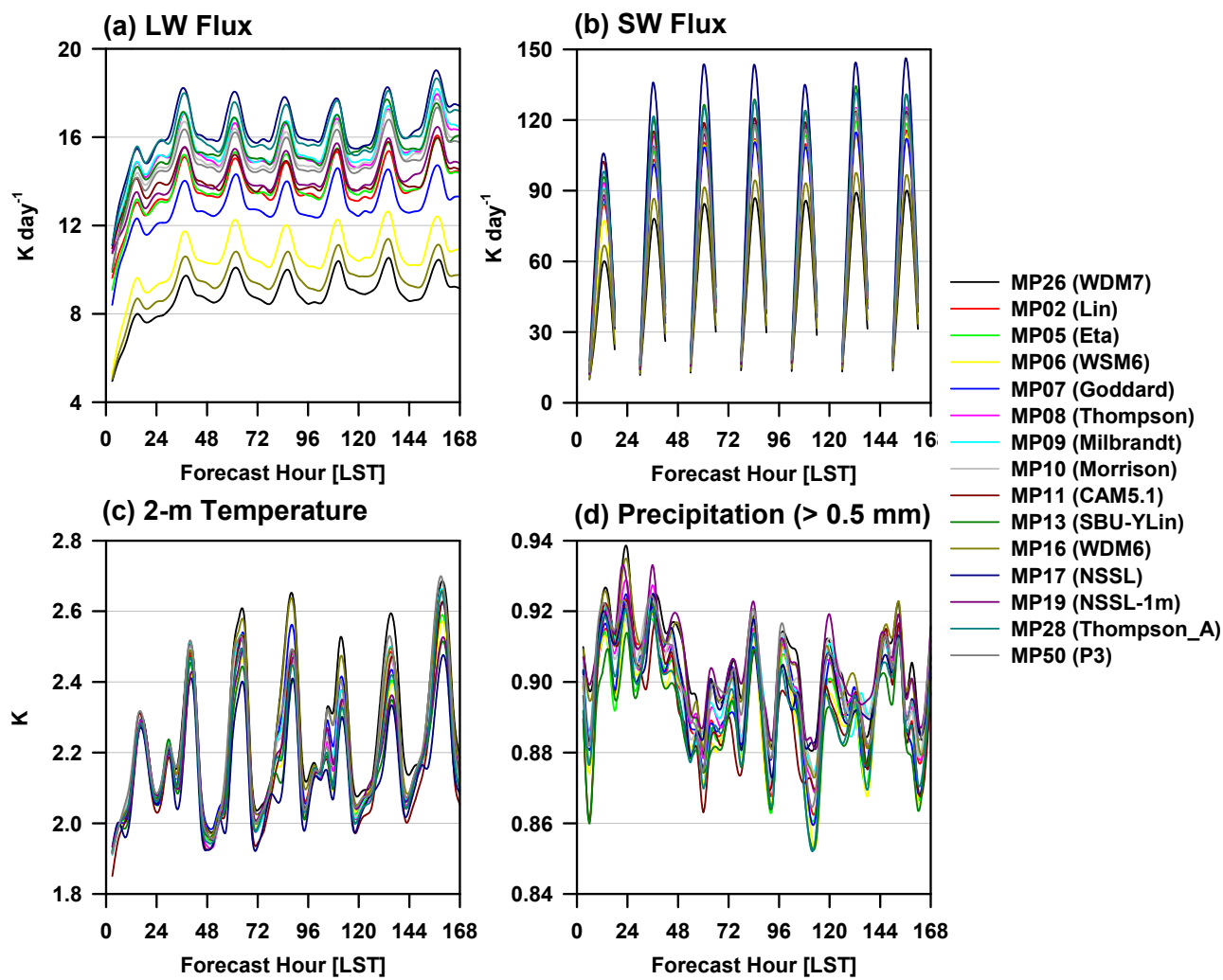


Figure S1. Same as Fig. 1, but for time series during 7 days.

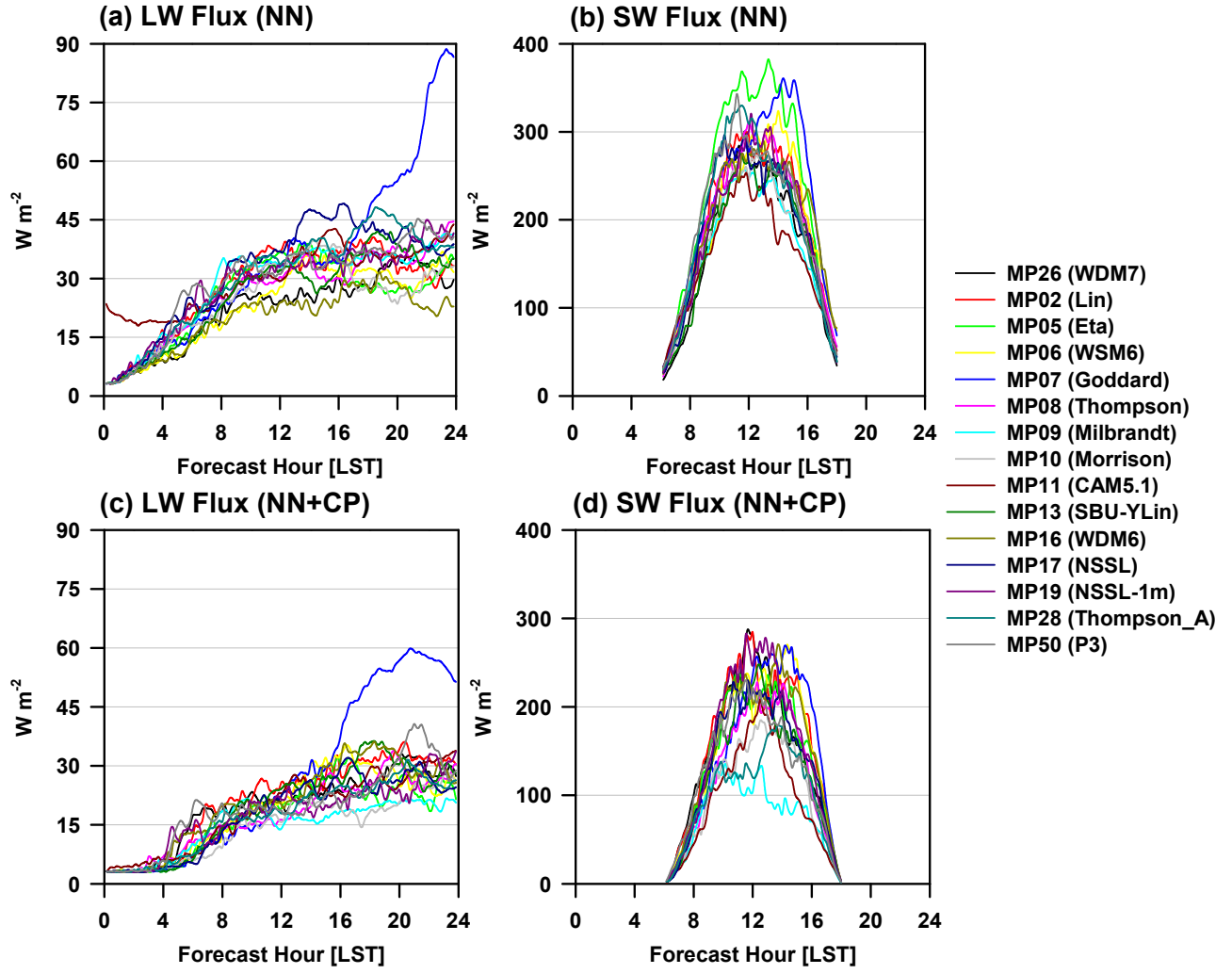


Figure S2. Same as Fig. 3, but for LW/SW fluxes.

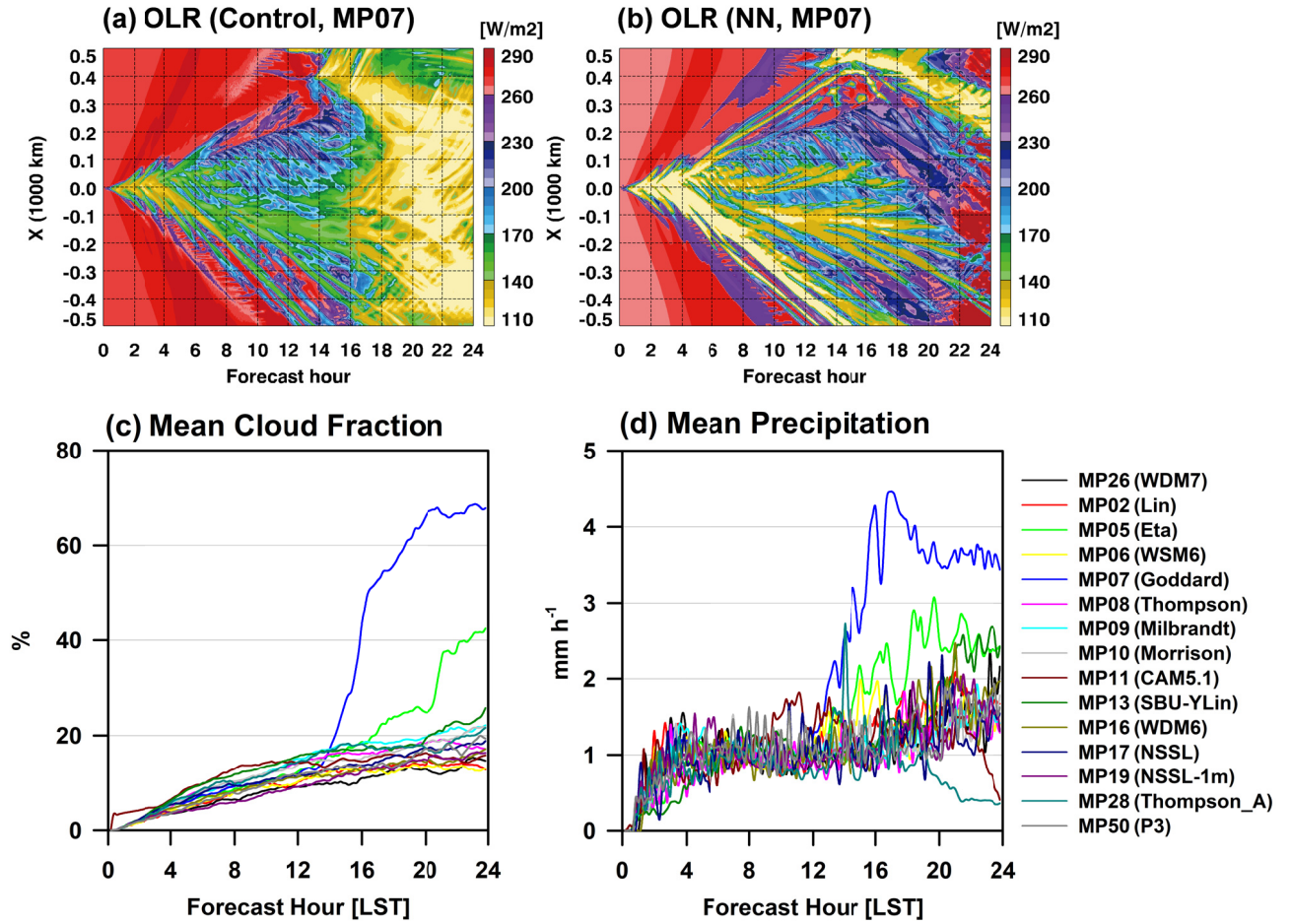


Figure S3. Evolutionary patterns of outgoing LW radiation (OLR) for (a) control run and (b) radiation emulator using the Goddard scheme. Time series of horizontal mean (c) column cloud fraction and (d) precipitation rate for 15 microphysics schemes.

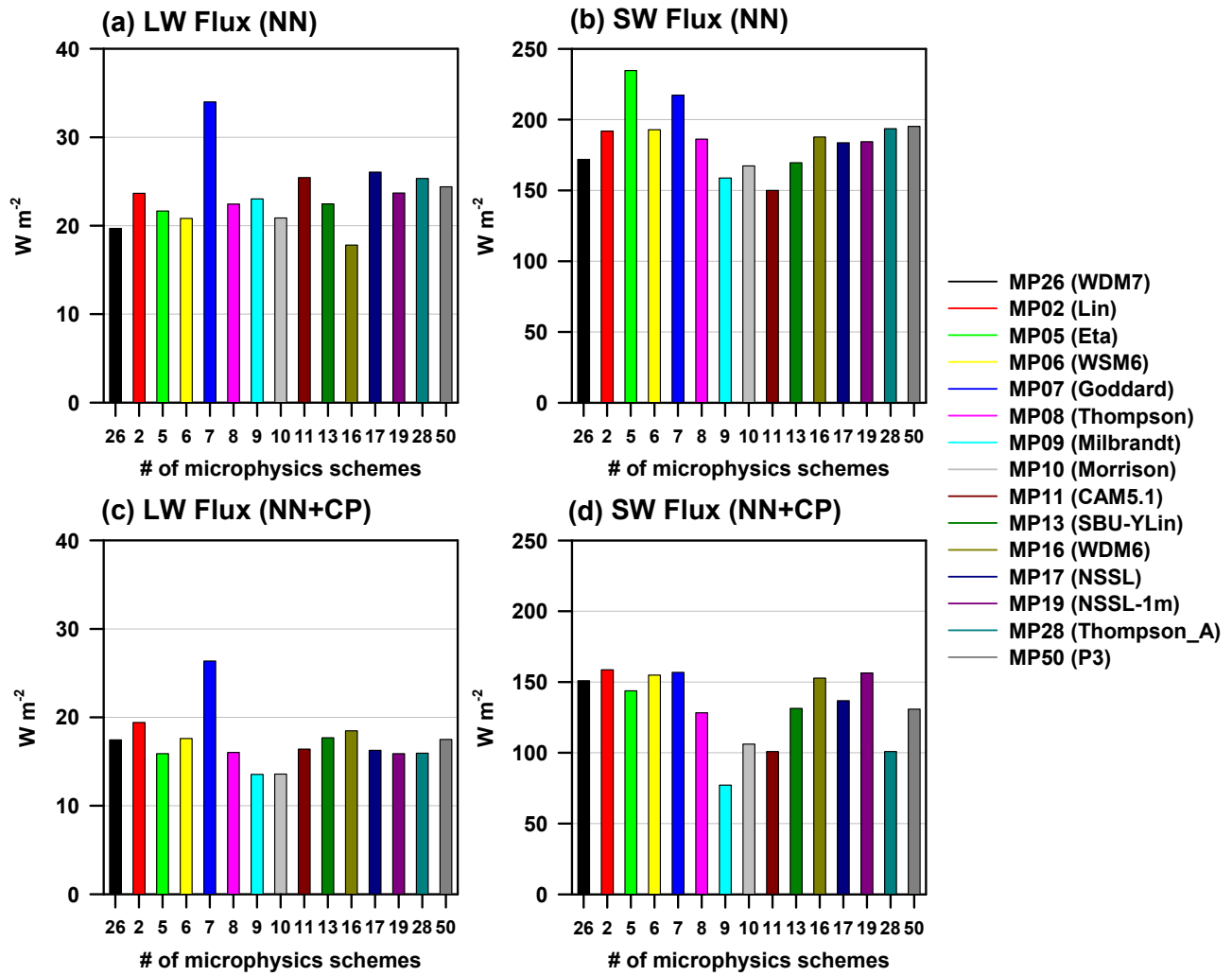


Figure S4. Same as Fig. 4, but for LW/SW fluxes.

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