

Table S1 Tunable parameters and their variability ranges for WRF model version 3.7.1.

Index	Scheme	Parameter	Default	Range	Description
P1		<i>xka</i>	2.4×10^{-5}	1.2×10^{-5} – 4.8×10^{-5}	The parameter related to heat/moisture exchange coefficient ($\text{m}^2 \text{s}^{-1}$)
P2	Surface layer (module_sf_sfclayrev.F)	<i>czo</i>	0.0185	0.00925– 0.037	The coefficient for converting wind speed to roughness length over water
P3		<i>znt_zf</i>	1	0.5–2	Scaling related to surface roughness
P4		<i>karman</i>	0.4	0.35–0.42	Von Kármán constant
P5		<i>pd</i>	1	0.5–2	Scaling related to downdraft mass flux rate
P6		<i>pe</i>	1	0.5–2	Scaling related to entrainment mass flux rate
P7	Cumulus convection (module_cu_kfeta.F)	<i>ph</i>	150	50–350	Starting height of downdraft above updraft source layer (hPa)
P8		<i>timec</i>	2700	1800–3600	Average consumption time of CAPE(s)
P9		<i>tkemax</i>	5	3–12	Maximum turbulent kinetic energy (TKE) value in sub-cloud layer($\text{m}^2 \text{s}^{-2}$)
P10		<i>ice_stokes_fac</i>	14900	7450– 29800	scaling factor applied to ice fall velocity(s^{-1})
P11	Microphysics (module_mp_wsm6.F)	<i>nor</i>	8×10^6	5×10^6 – 1.2×10^7	Intercept parameter related to raindrop (m^{-4})
P12		<i>dimax</i>	5×10^{-4}	3×10^{-4} – 8×10^{-4}	limiting maximum value for the cloud-ice diameter(m)
P13		<i>peaut</i>	0.55	0.35–0.85	collection efficiency from cloud to rain autoconversion
P14	Short-wave radiation (module_ra_rrtm_sw.F)	<i>cssca</i>	1×10^{-5}	5×10^{-6} – 2×10^{-5}	scattering tuning parameter ($\text{m}^2 \text{kg}^{-1}$)
P15	Long-wave radiation (module_ra_rrtm_lw.F)	<i>secang</i>	1.66	1.55–1.75	aerosol scattering tuning parameter $r(\text{m}^2 \text{kg}^{-1})$
P16		<i>hksati</i>	1	0.5–2	Scaling related to hydraulic conductivity at saturation
P17		<i>porsl</i>	1	0.5–2	Scaling related to the saturated soil water content
P18	Land surface (module_sf_noahlsf.F)	<i>phi0</i>	1	0.5–2	Scaling related to minimum soil suction
P19		<i>bsw</i>	1	0.5–2	Scaling related to Clapp and hornberegger “b” parameter
P20		<i>df11</i>	1	0.5–2	Scaling related to soil thermal conductivity
P21		<i>brcr_sbrob</i>	0.3	0.15–0.6	Critical Richardson number for boundary layer of water
P22		<i>brcr_sb</i>	0.25	0.125–0.5	Critical Richardson number for boundary layer of land
P23	Planetary boundary layer (module_bl_ysu.F)	<i>pfac</i>	2	1–3	Profile shape exponent of the momentum diffusivity
P24		<i>bfac</i>	6.8	3.4–13.6	Critical parameter for Prandtl number at the top of the surface layer
P25		<i>sm</i>	15.9	12–20	Countergradient proportional coefficient of non-local flux of momentum