README file TAMU_WRF_FSBM2

This README file is intended to describe and detail the model configuration and metadata related to the model output variables for the one-way nested WRF real-data case simulations at 2000 m and 500 m grid spacing for the outer and inner grids, respectively. The model output is written to individual files for each nested grid and time.

The following model configuration corresponds to the runs performed with WRF Model Version 4.6.1 and WRF Pre-Processing System Version 4.6.0 with initial and boundary conditions specified from the ERA5 0.25° x 0.25° reanalysis data. The WPS and WRF namelist files for each simulation have been copied in corresponding directories along with the model output on the NERSC DTN repository.

The model setup for all six simulations (three per golden case day) was specified as per the TRACER-MIP guidelines provided in Table 1 of the roadmap. Any deviations from these settings and/or additional clarifications are provided in Table R1 below:

Table R1

Model option	Option value	Remarks
Map projection	Lambert conformal	
Number of horizontal grid points in each nest	751 (outer grid) 501 (inner grid)	
Vertical levels	1, 0.997281524, 0.991349823, 0.985132077, 0.978620877, 0.971808069, 0.96468333, 0.957238058, 0.949461806, 0.94134381, 0.93287261, 0.924036712, 0.91482499, 0.905224697, 0.895220919, 0.884800793, 0.873952338, 0.862663831, 0.850923288, 0.838718486, 0.826038278, 0.812872641, 0.799212234, 0.785050678, 0.770383956, 0.755207933, 0.739516994, 0.723308528, 0.70658285, 0.689341952, 0.671589697, 0.653332035, 0.634577422, 0.615333894, 0.59560858, 0.575415501, 0.554778612, 0.533706378, 0.512332098, 0.491253747, 0.470861545, 0.451087422, 0.431911273, 0.41331667, 0.39528928, 0.377815647, 0.360882975, 0.344479656, 0.328594332, 0.313213466, 0.298323946, 0.283913946, 0.269972317, 0.256488998, 0.243454489, 0.230859708, 0.218695459, 0.206951868, 0.195619322, 0.18468737, 0.174146524, 0.163988038, 0.154202046, 0.144777641, 0.135703351, 0.126968205, 0.118561806, 0.110475292, 0.102705177, 0.095251681, 0.088114614, 0.081289478, 0.074766514, 0.068536138, 0.062589676, 0.056924791, 0.051542007, 0.046438723, 0.04160484, 0.03702495, 0.032682925, 0.028560837, 0.024625257, 0.0208677, 0.017301189, 0.01392253, 0.010723827, 0.00769352, 0.006649678, 0.005605837, 0.004561996, 0.003518154, 0.002474313, 0.001430472, 0.0	95 Eta levels specified in the WRF namelist
Geographic/topography data	30 s resolution for both grids	
Land-surface model	Option 2 for both grids	Unified Noah LSM
Cloud microphysics	Option 30 for both grids	FSBM2
Diffusion/PBL	diff_opt = 1 for both grids km_opt = 4 for both grids	

LW and SW Radiation	ra_lw_physics = 4 for both grids ra_lw_physics = 4 for both grids	RRTMG scheme RRTMG scheme
Aerosol size distribution	2 modes with the median diameter, mode sigma, and total number concentration defined as per Table 3 in the roadmap.	Defined on a mass-doubling grid with 43 bins
Aerosol assumptions	Two-mode lognormal distribution	Tier 2: Interactive aerosols during model integration
Aerosol hygroscopicity (kappa)	0.26	Each mode has the same kappa value
Hydrometeor categories	Category 1: rain/cloud Category 2: snow Category 3: hail Category 4: ice (plates, dendrites, and columns)	Defined on a mass-doubling grid with 33 bins for each hydrometeor category. Terminal fall speed values for all hydrometeor species based on the lookup table (see Fig. 1 below).
Initial and boundary aerosol conditions	Same as illustrated in Figure 4 of the roadmap.	The vertical aerosol profiles are specified in cm^{-3}

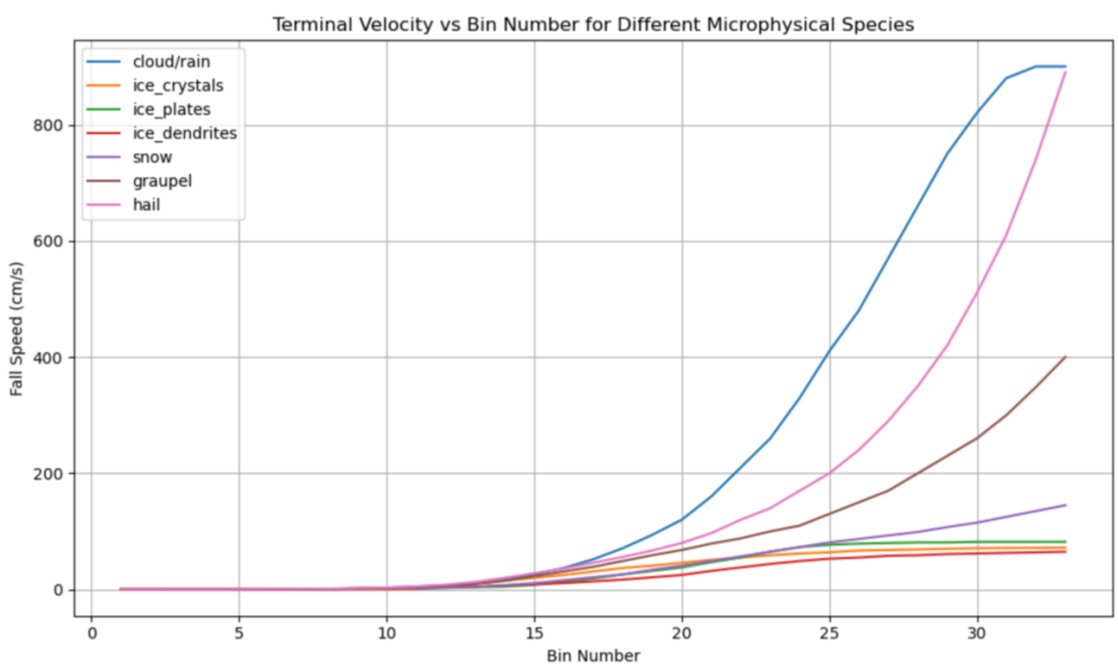

Fig. 1 Terminal fall speed for different microphysical species in the fast spectral-bin microphysics (FSBM-2) scheme used for TAMU's TRACER-MIP simulations.

The maximum radius of a dry AP is 2μm and 43-bins are used for the CCN size spectra. The utilization of 43 mass bins allows a higher resolution within the range of ultrafine AP that can activate to droplets at high supersaturations, well above cloud base. The minimum CCN size is assumed to be as low as 0.003 μm. All relevant microphysical processes/interactions, including droplet nucleation, condensation/evaporation of drops, deposition/sublimation of ice particles, and mutual collisions between the various hydrometeors, are calculated explicitly. Heterogeneous deposition/condensation ice nuclei activation is described using an empirical expression suggested by Meyers et al. (1992). The diffusion growth/evaporation of droplets and the deposition/sublimation of ice particles are calculated using analytical solutions for supersaturation with respect to water and ice. The rate of drop freezing is calculated using the empirical formula created by Bigg (1953). An efficient and accurate method of solving the stochastic kinetic equation for collisions (Bott, 1998) is used for a system of stochastic kinetic equations calculating water-ice and ice-ice collisions. The model uses height-dependent drop-drop and drop-graupel collision kernels following Khain et al. (2001) and Pinsky et al. (2001). Ice-ice collection rates are assumed to be temperature-dependent (Pruppacher and Klett, 1997). Secondary ice generation is described following observations by Hallett and Mossop (1974) and Mossop (1976; the HM mechanism). Melting is described using a simple parameterization proposed by Fan et al. (2010) and used in several intercomparison studies (Fan et al., 2015; Han et al., 2019).

Please refer to Shpund et al. (2019) for more details.

Relevant references:

Khain, Alexander, and Barry Lynn. "Simulation of a supercell storm in clean and dirty atmosphere using weather research and forecast model with spectral bin microphysics." Journal of Geophysical Research: Atmospheres 114.D19 (2009).

Shpund, Jacob, et al. "Simulating a mesoscale convective system using WRF with a new spectral bin microphysics: 1: Hail vs graupel." Journal of Geophysical Research: Atmospheres 124.24 (2019): 14072-14101.

Fan, Jiwen, et al. "Improving representation of convective transport for scale-aware parameterization: 1. Convection and cloud properties simulated with spectral bin and bulk microphysics." Journal of Geophysical Research: Atmospheres 120.8 (2015): 3485-3509.

Units for different microphysical rates in the model output

Table R2 Description of units used for various microphysical terms in the output files

Variable name	Microphysical process	Units	Remarks
CONDENSATION	Droplet condensation	g/g	Per second (instantaneous)
ACOND	Accumulated condensation	g/g	Per output time interval
EVAPORATION	Droplet evaporation	g/g	Per second (instantaneous)
AEVAP	Accumulated evaporation	g/g	Per output time interval
DEPOSITION	Vapor deposition	g/g	Per second (instantaneous)
ADEP	Accumulated vapor deposition	g/g	Per output time interval
SUBLIMATION	Ice sublimation	g/g	Per second (instantaneous)
ASUB	Accumulated ice sublimation	g/g	Per output time interval
RIMING	Riming of ice particles/ Droplet accretion by ice	g/g	Per second (instantaneous)
ARIME	Accumulated riming	g/g	Per output time interval
MELTING	Total melting contribution of all ice species	g/g	Per second (instantaneous)
AMELT	Accumulated melting	g/g	Per output time interval
FREEZING	Total freezing of droplets and raindrops	g/g	Per second (instantaneous)
AFREEZE	Accumulated freezing	g/g	Per output time interval
ACCRETION	Total droplet accretion by liquid particles	g/g	Per second (instantaneous)
AACCRETION	Accumulated accretion	g/g	Per output time interval
RATEDROPNUCL	Rate of droplet nucleation	# g^{-1} s^{-1}	Instantaneous value at the output time step
RATEICENUCL	Rate of ice nucleation	# g^{-1} s^{-1}	Instantaneous value at the output time step
H_DIABATIC	Latent heating + cooling	K s^{-1}	Instantaneous latent heating + cooling