

TRACER Model Intercomparison Project ICON simulations

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Name of Model & Microphysics Parameterization:

ICOsahedral Non-hydrostatic (ICON) model version icon-2024.10

double-moment scheme of Seifert and Beheng (2006)

Seifert, A. and Beheng, K. D.: A two-moment cloud microphysics parameterization for mixed-phase clouds. Part I: Model description, Meteorol. Atmos. Phys., 92, 67–82, <https://doi.org/10.1007/s00703-005-0112-4>, 2006a.

Aerosol setup:

- fixed aerosols at each timestep
- largest possible value of median diameter of larger aerosol mode is 80 nm (instead of 136/175 nm)

Table 1: Power law coefficients for the maximum diameter $D(x) = ax^b$ and the terminal fall velocity $v(x) = \alpha x^\beta$ of particles with mass x as well as coefficients of the generalized Gamma distribution $f(x) = Ax^\nu \exp(-Bx^\mu)$ and maximum and minimum values for the mean particle mass \bar{x} for the various hydrometeor types as used in the SB two-moment microphysics scheme. Below cloud base the raindrops follow the size-dependent Gamma shape parameterization of Seifert (2008).

	a (m kg ^{-b})	b	α (m s ⁻¹ kg ^{-β})	β	ν	μ	\bar{x}_{\min} (kg)	\bar{x}_{\max} (kg)	particle class
cloud	0.124	1/3	3.75×10^5	2/3	1	1	4.2×10^{-15}	2.6×10^{-10}	cloud_nue1mue1
rain	0.124	1/3	114.0137	0.234	1	1/3	2.6×10^{-10}	6.5×10^{-5}	rainSBB
ice	0.835	0.390	27.7	0.216	0	1/3	1.0×10^{-12}	1.0×10^{-5}	ice_cosmo5
snow	5.130	0.500	400.0	0.350	1	1/2	1.0×10^{-10}	2.0×10^{-5}	snowSBB
graupel	0.142	0.314	100.0	0.34	1	1/3	4.19×10^{-9}	5.3×10^{-4}	graupelhail_cosmo5
hail	0.1366	1/3	39.30	0.167	1	1/3	2.6×10^{-9}	5.0×10^{-3}	hail_cosmo5

The generalized Γ -distribution can be written as a function of number and mass densities (Seifert and Beheng, 2006):

$$f(x) = \frac{N}{\bar{x}} \left[\frac{x}{\bar{x}} \right]^\nu \frac{\mu}{\Gamma\left(\frac{\nu+1}{\mu}\right)} \left[\frac{\Gamma\left(\frac{\nu+2}{\mu}\right)}{\Gamma\left(\frac{\nu+1}{\mu}\right)} \right]^{\nu+1} \times \exp \left\{ - \left[\frac{\Gamma\left(\frac{\nu+2}{\mu}\right)}{\Gamma\left(\frac{\nu+1}{\mu}\right)} \frac{x}{\bar{x}} \right]^\mu \right\} \quad \text{in } \frac{1}{\text{m}^3 \text{kg}}$$

x : mass of particles in kg

N : number density of cloud droplets QNC in 1/m³

L : mass density of cloud droplets=cloud water content QC in kg/m³

$\bar{x} = \frac{L}{N}$ mean particle mass in kg

density of water: 1000.0 kg/m³; density of ice: 916.7 kg/m³

Output variables and file names

10-min full simulation:

NWP_LAM_DOM01_2022MMDDTHHMSSZ_TRACER_10min_reglatlon.nc.nc

MM: month; DD: day; T: Time; HH: hour; MM: min; SS: sec

2-min from 1700 UTC event day - 0100 UTC next day:

NWP_LAM_DOM01_2022MMDDTHHMSSZ_TRACER_2min_reg_latlon.nc.nc

field	meaning	unit
pres	pressure	Pa
temp	temperature	K
u	zonal wind speed (east is -)	m s^{-1}
v	meridional wind speed (north is -)	m s^{-1}
w	vertical wind speed (up is +)	m s^{-1}
qv	specific water vapor content	kg kg^{-1}
qc	specific cloud water content	kg kg^{-1}
qnc	number concentrations cloud droplets	$\# \text{kg}^{-1}$
qr	specific rain content	kg kg^{-1}
qnr	number concentrations rain droplets	$\# \text{kg}^{-1}$
qi	specific cloud ice content	kg kg^{-1}
qni	number concentrations cloud ice	$\# \text{kg}^{-1}$
qs	specific snow content	kg kg^{-1}
qns	number concentrations snow	$\# \text{kg}^{-1}$
qg	specific graupel content	kg kg^{-1}
qng	number concentrations graupel	$\# \text{kg}^{-1}$
qh	specific hail content	kg kg^{-1}
qnh	number concentrations hail	$\# \text{kg}^{-1}$
z_ifc	height 95 half levels (for vertical wind speed w)	m agl
z_mc	height 94 model levels (all variables except w)	m agl
topography_c	topography	m agl
tot_prec_rate	instantaneous surface precipitation rate	mm s^{-1}
rain_gsp_rate	instantaneous surface rain rate	mm s^{-1}
ice_gsp_rate	instantaneous surface ice rate	mm s^{-1}
snow_gsp_rate	instantaneous surface snow rate	mm s^{-1}
graupel_gsp_rate	instantaneous surface graupel rate	mm s^{-1}
hail_gsp_rate	instantaneous surface hail rate	mm s^{-1}
tot_prec	surface precipitation (time-integrated)	mm
rain_gsp	surface rain (time-integrated)	mm
ice_gsp	surface ice (time-integrated)	mm
snow_gsp	surface snow (time-integrated)	mm
graupel_gsp	surface graupel (time-integrated)	mm
hail_gsp	surface hail (time-integrated)	mm
pres_msl	sea-level pressure	Pa
lhfl_s	instantaneous surface latent heat flux	W m^{-2}
shfl_s	instantaneous surface sensible heat flux	W m^{-2}
alhfl_s	surface latent heat flux mean since model start	W m^{-2}
ashfl_s	surface sensible heat flux mean since model start	W m^{-2}
alb_dif	shortwave albedo for diffuse radiation	
thu_s	Longwave upward flux SFC	W m^{-2}
thu_t	Longwave upward flux TOA	W m^{-2}
thd_s	Longwave downward flux SFC	W m^{-2}
thd_t	Longwave downward flux TOA	W m^{-2}
sou_s	Shortwave upward flux SFC	W m^{-2}
sou_t	Shortwave upward flux TOA	W m^{-2}
sod_s	Shortwave downward flux SFC	W m^{-2}
sod_t	Shortwave downward flux TOA	W m^{-2}
t_2m	2-m temperature	K
u_10m	10-m zonal wind speed (east is -)	m s^{-1}
v_10m	10-m meridional wind speed (north is -)	m s^{-1}
all following variables are time-integrated over simulation time		
d_lhr	latent heating and cooling	K time^{-1}

d_satad_cond	condensation from first saturation adjustment	kg kg ⁻¹ time ⁻¹
d_satad_evap	evaporation from first saturation adjustment	kg kg ⁻¹ time ⁻¹
d_satad2_cond	condensation from second saturation adjustment	kg kg ⁻¹ time ⁻¹
d_satad2_evap	evaporation from second saturation adjustment	kg kg ⁻¹ time ⁻¹
d_qr_evap	rain evaporation	kg kg ⁻¹ time ⁻¹
d_qi_dep	vapor deposition on ice	kg kg ⁻¹ time ⁻¹
d_qs_dep	vapor deposition on snow	kg kg ⁻¹ time ⁻¹
d_qg_dep	vapor deposition on graupel	kg kg ⁻¹ time ⁻¹
d_qh_dep	vapor deposition on hail	kg kg ⁻¹ time ⁻¹
d_qi_sub	sublimation of ice	kg kg ⁻¹ time ⁻¹
d_qs_sub	sublimation of snow	kg kg ⁻¹ time ⁻¹
d_qg_sub	sublimation of graupel	kg kg ⁻¹ time ⁻¹
d_qh_sub	sublimation of hail	kg kg ⁻¹ time ⁻¹
d_qr_melt	rain production by melting of all frozen hydrometeors	kg kg ⁻¹ time ⁻¹
d_qc_melt	ice melting to cloud droplets	kg kg ⁻¹ time ⁻¹
d_qr_rf	rain freezing to snow, graupel, hail	kg kg ⁻¹ time ⁻¹
d_qg_rf	graupel formation from rain freezing	kg kg ⁻¹ time ⁻¹
d_qi_rf	rain freezing to ice	kg kg ⁻¹ time ⁻¹
d_qh_rf	rain freezing to hail	kg kg ⁻¹ time ⁻¹
d_qc_nuc	cloud droplet nucleation	kg kg ⁻¹ time ⁻¹
d_qi_hom	Homogeneous freezing of liquid water droplets	kg kg ⁻¹ time ⁻¹
d_qi_homhet	immersion freezing and homogeneous freezing of liquid aerosols	kg kg ⁻¹ time ⁻¹
d_qc_rime_i	riming of ice with cloud droplets	kg kg ⁻¹ time ⁻¹
d_qc_rime_s	riming of snow with cloud droplets	kg kg ⁻¹ time ⁻¹
d_qc_rime_gh	riming of graupel, hail with cloud droplets	kg kg ⁻¹ time ⁻¹
d_qr_rime_i	riming of ice with rain droplets	kg kg ⁻¹ time ⁻¹
d_qr_rime_s	riming of snow with rain droplets	kg kg ⁻¹ time ⁻¹
d_qr_rime_gh	riming of graupel, hail with rain droplets	kg kg ⁻¹ time ⁻¹
d_qr_ac	autoconversion	kg kg ⁻¹ time ⁻¹
d_qr_acc	accretion	kg kg ⁻¹ time ⁻¹
d_qsh_evap	evaporation of melting snow, graupel, hail	kg kg ⁻¹ time ⁻¹

In addition to the instantaneous surface fluxes of sensible (shfl_s) and latent (lhfl_s) heat, the average values over the forecast time are also stored (ashfl_s, alhfl_s). The mean value between two times t_1 and t_2 can be calculated as follows:

$$\text{shfl}_s = \frac{1}{t_2 - t_1} \cdot [t_2 \cdot \text{ashfl}_s(t_2) - t_1 \cdot \text{ashfl}_s(t_1)]$$