Improving numerics of two-moment bulk microphysics schemes: Warm rain processes

I. Sednev (isednev@lbl.gov), S. Menon (smenon@lbl.gov)

Lawrence Berkeley National Laboratory, Berkeley, CA, USA

Summary

We highlight that most two-moment bulk cloud microphysics schemes (BLK) implemented in models such as the Weather Research and Forecasting (WRF) model or CAM are not positive definite and might show better performance for finer spatial resolutions when time steps used to advance microphysical prognostic equations have an order of magnitude from seconds to tenths of seconds.

For coarser spatial resolutions time steps are usually increased from hundredths up to thousands of seconds, but it might lead to degradation of BLK performance because of corrections such as "mass adjustment" (for single-moment schemes) and additional "concentration adjustment" (for double moment schemes), which are artificial.

To circumvent the problem we are developing an adaptive substepping (ADSS) technique based on analytic stability and positive definiteness criteria and analyze numerics of warm rain processes in different bulk microphysics (BLK) schemes implemented in the model such as WRF.

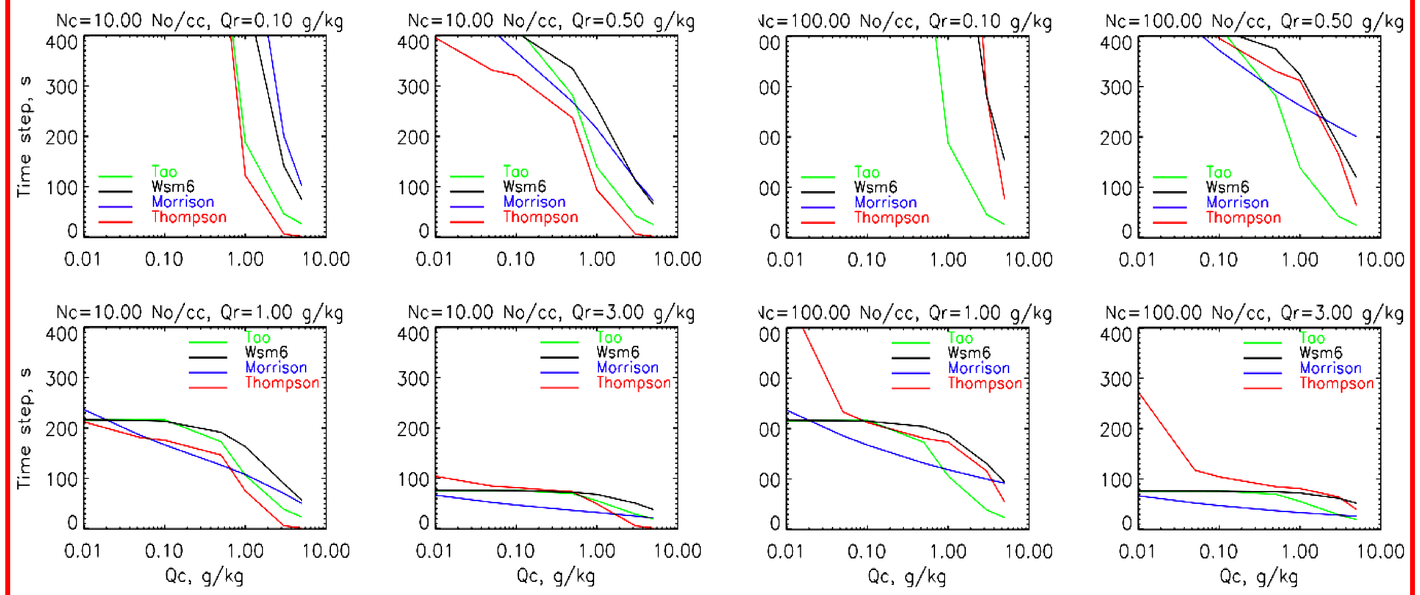
We implement description of warm rain processes based on Eulerian explicit (EE) time integration in WRF BLK schemes into our microphysics package as a standalone program. We use sensitivity runs with EE and ADSS schemes for a wide range of cloud (Qc**)** and rain (Qr) water contents and droplet concentration (Nc) to calculate auto-conversion and accretion growth rates as well as critical (max) time steps permitted to keep positiveness of the schemes. Similar work in ongoing for CAM.

Max time steps, s

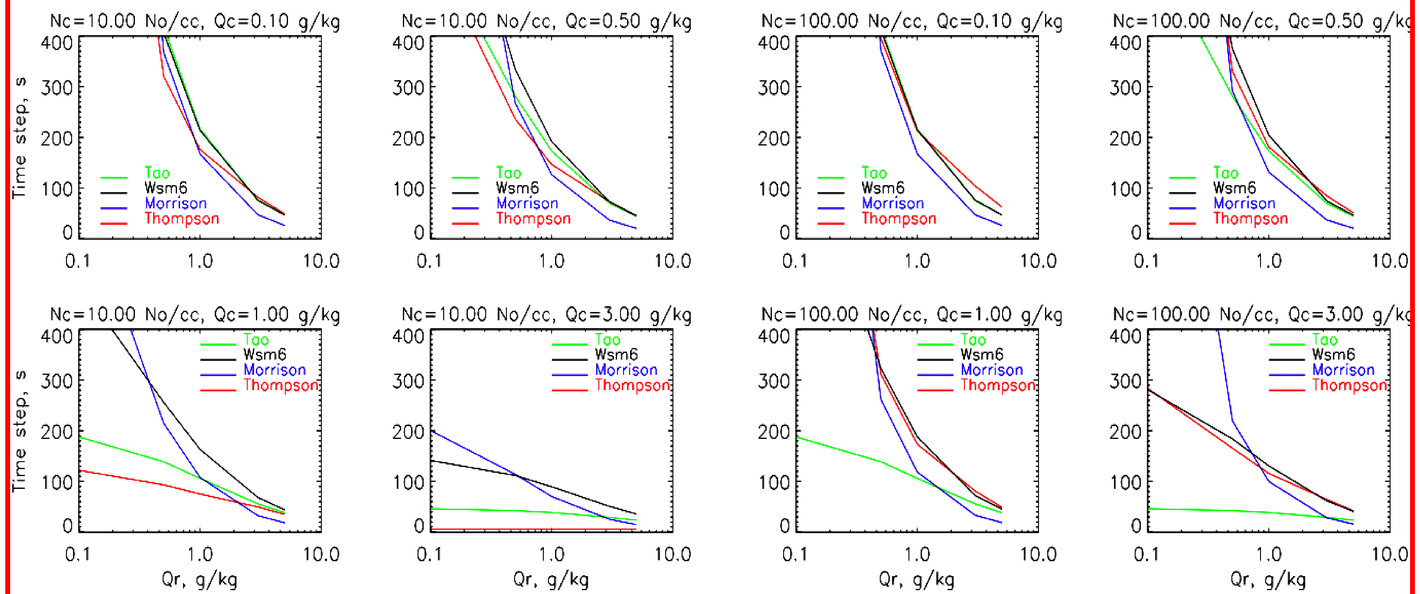
SCHEME	AUTOCONVERSION	ACCRETION	MAX
TAO	860 / 860	418 / 418	281 / 281
WSM6	>1000 / >1000	418 / 418	334 / 412
MORRISON	>1000 / > 1000	292 / 292	268 / 292
THOMPSON	949 / > 1000	314 / 331	236 / 330
KESSLER	>1000 / >1000	351 / 351	351 / 351
LIN	1000 / 1000	418 / 418	295 / 295□□
ETAnew	>1000 / >1000	374 / 381	278 / 352
BEHENG	470 / >1000	333 / 333	195 / 333
SIEFERT	>1000 / >1000	347 / 347	282 / 347
SIEFERTnew	>1000 / >1000	381 / 381	352 / 380
Rasch_CAM	>1000 / >1000	375 / 375	287 / 329

Autoconversion,, accretion, and max time steps permitted to keep positive definiteness in different WRF bulk microphysics schemes for Qc=1.0 g/kg, Qr=0.5 g/kg, Nc=10 / 100 No/cc.

Critical time step dependence on Qr and Nc



Critical time step dependence on Qc and Nc



Acknowledgements: ***This work was supported by the Office of BER of US DOE as part of the ASR and ESM Program. We gratefully acknowledge support from Kiran Alapaty (ASR).***