American Meteorological Society Meeting Seattle, WA, January, 2011 Poster Number : 733

Evaluating Aerosol-Cloud and Cloud-Radiation interaction simulations with a Single Column Model (SCM) using McRAS cloud physics with ARM data and satellite retrievals

We have used cloud physics of McRAS-AC (NASA's microphysical cloud scheme with Relaxed Arakawa Schubert cloud parameterization Liquid (black), Ice+0.3 (green); Summer (solid), Winter (dashed) upgraded with aerosol-cloud interaction physics) in a single column (SCM) version of GEOS-4 GCM together with following modules to 📥 SCM 100 simulate realistic aerosol-cloud-radiation interactions effects emanating from activated aerosols as CCN and/or IN. MODIS 2 80 **Fountoukis and Nenes (2005)** Ice and mixed phase clouds **Aerosol activation for liquid clouds** 60 Homogeneous ice nucleation by sulfate **Khovorstynov and Curry (1999) Cloud particle size distribution** 20 **Heterogeneous ice nucleation including** Liu and Penner (2005) **Contact freezing, Immersion freezing,** Jan tep Wat Way Way nou in the tradition of Mon Dec Jar Feb Wat bot Way Jur Juj Brid Zeb Oct Mon Dec **Aerosol activation for ice clouds Deposition by dust and black carbon** 15 20 25 30 35 Micron Sud and Lee (2007) SCM_^ **Bergeron-Findeisen process and direct** SCM 2 **Precipitation microphysics** Figure 4. Cloud effective radius & optical thickness deposition of water vapor for mixed simulated by SCM and compared against long-term MODIS measurement (2000-2009) over ARM-SGP. phase clouds Liquid effective radius and optical thickness agrees + McRAS = McRAS-AC ----- Kramer reasonably well with the satellite observations. Left figure shows yearly averaged ice concentration simulated by the • We have incorporated mass and number of liquid and ice inside the convective tower for the first time ever to simulate aerosol-cloudmodel, with large scale concentration in solid line and radiation interaction inside the tower and in large-scale clouds. convective in dashed line are compared against Kramer • With limited observations available to validate SCM, it does reasonable well to simulate cloud optical properties and radiations. (2009) aircraft data (in red). SCM simulates ice number 1/10 of observation with effective radius of ~70 micron. • SCM is evaluated over the ARM-SGP site (using 1999-2001 3 year continuous forcing data) while the in situ ARM-observations and Jan rep war and way in in the and ceb oct way bec satellite measurements were compared against the model simulations. e Number Concentration (#/cm³) Time Series **Convective Liquid Mass** Large Scale Liquid Mass **Convective Liquid Number** SCM simulated (black) and Observed (green); Precipitation (mm/day); JJA 1999 0 0.06 0.12 0.18 0.24 0 0.02 0.04 0.08 0.08 # cm-3 g/kg Jan kep war bor way in in the brog deb oct won dec Time Average Figure 1. Total precipitation (mm/day) in summer (JJA) months (1999) are compared against ARM in-situ observations (*left*) and rainfall climatology compared Large Scale Liquid Number **Convective Ice Mass Convective Ice Number** against TRMM (3B43 V6) long-term (1998-2010) monthly dataset (right) SCM simulated (red), ARM surface observation (green); OLR (w/m2); JJA 2001 SCM 320 305 √290 √s 275 ₹²⁶⁰ <u>د</u> 245 O₂₃₀ à 0.001 0.002 0.003 0. 0.005 0.01 0.015 cm-3 215 Figure 5. Time series of SCM simulated convective and large Scale liquid and ice number (#/cm³) and mass (g/kg) averaged for 3 year summer months 200 -Jan rep war bor way in in the brad es oct hos bec **Ice Number** Liquid Number **Liquid Mass** Ice Mass GrADS: COLA/IGE Figure 2. Outgoing Longwave Radiation (all-sky) (OLR) in Wm⁻² for summer (JJA) months (2001) are compared against ARM in-situ observations (*left*) and climatology compared against CERES (2002-2005) and AIRS dataset (2002-2010) (*right*) Sim. SW(magenta),LW (purple),Tatal Moist Heating (aqua); JJA (solid), DJF (dash) SCM simulated (red), ARM ground observation (green); JJA 2000 120 150 180 210 240 0.003 0.006 0.009 0.012 0.015 0.018 0.021 0.024 # cm⁻³ (g/kg)# cm⁻³ $\left(\frac{q}{kq}\right)$ GrADS: COLA/IGES Figure 6. SCM simulated convective and large Scale liquid and ice number (#/cm³) and mass (g/kg) averaged for 3 year summer (JJA) and winter (DJF) months. In the figure convective is (blue), Large Scale is (red) and solid for summer moths and dashed lines for winter months. • Results show current SCM parameterizations result realistic annual mean and cycles of cloud water, optical and radiational properties that lead to conduct aerosol-cloud-radiation interaction experiments using GEOS-4 GCM over monsoon areas. GrADS: COLA/IGES K/dav • Compare and improve ice activation physics in the model with Barahona and Nenes against current Liu and Penner ice parameterizations Figure 3. Integrated cloud fraction simulated by SCM compared against GEOS measurement for (JJA) months (2000) (*left*) and LW, SW and moist heating rates









(K/day) are averaged for 3 year summer (JJA) and winter (DJF) months. Summer months in solid lines, while winter months are dashed Acknowledgements: This work is funded by NASA Earth and Space Science Fellowship (NESSF) grant NNX08AV02H

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