In this exercise, the student will use the idealized model CM1 to demonstrate relationships between MCS structure and evolution, and (1) the characteristics of the environmental wind shear, (2) the presence of planetary rotation, and (3) the presence of frozen hydrometeors.

Suggested experiments

Conduct separate model experiments with environmental wind profiles characterized by unidirectional vertical wind shear U_s (= 10, 15, 20, and 25 m s^{-1}) over layer depth D (= 2.5 and 5 km) and comment on the:

(a) degree of organization of cells into a (nearly) continuous convective line, (b) symmetry of the line, (c) presence and strength of a rear-inflow jet, and (d) presence of low-level mesovortices (and hence the magnitude and line-relative location of the maximum low-level vertical vorticity).

For a specific U_s and D, conduct additional experiments in which Coriolis parameter f = 0.001 s^{-1}, and in which the Morrison double-moment microphysics parameterization scheme is used in place of the rain-only Kessler microphysics parameterization scheme (`ptype = 5` in the *namelist.input* file).

Model setup and other instructions

Installation, setup, and execution of this CM1 is fairly straightforward (see: http://www.mmm.ucar.edu/people/bryan/cm1/). A typical Linux workstation will be sufficient to execute this numerical model.

The preceding experiments assume a computational domain defined by:

`nx = ny = 200; nz = 36`

`dx = dy = 1000.; dz = 500.`

An option to translate the domain at some constant speed in included in the *namelist.input* file. The default settings are

`umove = 22.5 , vmove = 0`

Change these as necessary to keep the squall line well within the computational domain.

The "Weisman-Klemp" analytic sounding is used, and the environmental winds are specified as unidirectional through namelist variable `iwnd = 1`. These and other parameters are defined in *namelist.input* file (as can be obtained from

http://web.ics.purdue.edu/~jtrapp/namelist.input.sqline

and then be copied to *namelist.input*).

Note that to allow for comparison with previous studies (e.g., Weisman and Trapp 2003), this model setup assumes rain-only precipitation, via the "Kessler" microphysical parameterization scheme (`ptype = 1`), and no planetary rotation (`icor = 0`). To include planetary rotation, set `icor = 1`; it is assumed in the *namelist.input.sqline* file that the Coriolis force is applied only to the perturbation quantities (`percor = 1`) and that the Coriolis parameter has a value of 10^{-4} s^{-1} (`fcor = 0.0001`). Finally, convection is initiated by three warm bubbles that are aligned perpendicular to the vertical wind shear vector.

The *namelist.input.sqline* file takes advantage of the CM1 option to modify the nonstandard parameters. Here:

`var1` = vertical depth of linearly increasing unidirectional shear (m) (model variable **udep2**)

`var2` = value of (unidirectional) environmental wind at height **udep2** (m s^{-1}) (model variable **uconst2**)

`var3` = height of center of bubble above ground (m) (model variable **zc**)

`var4` = horizontal radius of bubble (m) (model variable **bhrad**)

`var5` = vertical radius of bubble (m) (model variable **bvrad**)

`var6` = max potential temp perturbation (K) (model variable **bptpert**)

`var7` = center of bubble in *x*-direction (model variable **ric**)

`var8` = number of bubbles (model variable **nbub**)

These parameters are set in the source file *base.F* and *init3d.F* in directory src (e.g., use http://web.ics.purdue.edu/~jtrapp/base.F and http://web.ics.purdue.edu/~jtrapp/init3d.F when compiling the model).

One software application that can be used to display the model output is NCL (see http://www.ncl.ucar.edu).

An example script can be obtained from http://web.ics.purdue.edu/~jtrapp/cmplotxy-sl.ncl

The output (as a pdf file, by default) shows horizontal cross-sections, at two different levels, of: vertical velocity and winds, and rain-water mixing ratio and winds.