**Trajectory Code Instructions**

To run a simulation with trajectories enabled you must have the namelist variable ‘traj\_opt’ in the physics namelist group set to 1:

 traj\_opt = 1 on a per domain basis.

The number of trajectories can be set in the namelist in the &domains group (default is 1000).

The trajectory code must be included from the beginning of the WRF simulation. However, note that you can conduct a “cold start” simulation part way through a simulation by initializing from the WRF output of the desired starting time. For example, if the simulation begins at 00 UTC 1 June and you want the trajectories to begin at 12 UTC 2 June, then the output from the simulation at 12 UTC 2 June can be used as wrfinput data for a new simulation. Restarts will continue the trajectory during the simulation. If the trajectory start time begins after the start of the WRF simulation, then missing values will be assigned to the trajectory variables (except for i, j, k, latitude, longitude, and altitude).

The trajectories exist in only the domain that they are assigned. When the trajectory exits the domain, missing values are assigned to the trajectory variables.

To initialize trajectories, a trajectory namelist input file, named wrfinput\_traj\_d<nn>, for each domain is used.

There is an example wrfinput\_traj\_d01 file at the end of this documentation that can be used as a template. Please note the following:

(1) You are allowed a maximum of 1000 trajectories per domain (defined in namelist.input in &domains section)

(2) The traj\_default namelist group in wrfinput\_traj\_d<nn> is optional but must be included in wrfinput\_traj\_d<nn> even if you do not want to specify any defaults; in this case you have a "null" default group as in :

&traj\_default

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(3) the traj\_default namelist group is composed of the following variables :

traj\_def%start\_time, a character, scalar of length 19

traj\_def%stop\_time. a character, scalar of length 19

traj\_def%dyn\_name, a character, array of length 100; each is char(len=32)

traj\_def%hyd\_name, a character, array of length 100; each is char(len=32)

traj\_def%chm\_name, a character, array of length 100; each is char(len=32)

traj\_def%trc\_name, a character, array of length 100; each is char(len=32)

(4) the traj\_spec namelist group is required

(5) the traj\_spec namelist group is composed of traj\_type user defined variables. There are a maximum of 100 traj\_type variables per traj\_spec namelist group. Each traj\_type type is composed of :

start\_time, a character, scalar of length 19

stop\_time, a character, scalar of length 19

lon, a real, scalar

lat, a real, scalar

lev, a real, scalar

dyn\_var, a character, array of length 100; each is char(len=32)

hyd\_spc, a character, array of length 100; each is char(len=32)

chm\_spc, a character, array of length 100; each is char(len=32)

trc\_spc, a character, array of length 100; each is char(len=32)

NOTE: if defaults are specified and any of the traj\_type entries have unspecified start\_time, stop\_time, dyn\_var, hyd\_spc, chm\_spc, and/or trc\_spc variables the traj\_type variable entries will default to the traj\_default entries.

NOTE: the lon, lat, and lev variables have NO defaults and must be specified for each trajectory.

The lon, lat variables are WRF conforming and are in degrees.

The lev variable is the trajectory starting height in meters.

The dyn\_var entries are 'p', 'T', 'z', 'u', 'v', 'w', 'rainprod', 'evapprod'.

The hyd\_spc entries must match the names as given in the cloud physics package statement in registry.EM.COMMON. These are typically 'QVAPOR', 'QCLOUD', 'QRAIN', 'QICE', 'QSNOW', and 'QGRAUP'.

The chm\_spc entries must match the chemical species names as given in the chemical package statement in registry.chem. Note the use of 'ho', not 'oh', in wrfinput\_traj\_d01.

The trc\_spc entries must match the tracer species names as given in the tracer package statement in registry.chem.

**Output**

The trajectory output occurs every time step. Results are written to wrfout\_traj\_d<nn> files for each domain in your simulation with trajectories specified. These are netcdf files.

Output with values = -9999. signify "missing" output that occurred either because the simulation time is not in the start\_time, stop\_time interval or the trajectory has exited the domain.

Two-dimensional arrays are created for each variable specified in the namelist. These arrays are dimensioned number of time steps by number of trajectories. For example, the hydrometeor QCLOUD will have the following output array:

float QCLOUD\_traj(time, traj)

where time = number of time steps and traj = number of trajectories.

The variable ‘Times’ is a character array containing the time associated with each time step. The location of the trajectory always has a value. There are 5 2-d arrays for the grid location and latitude and longitude:

 float traj\_i(time, traj) ;

 float traj\_j(time, traj) ;

 float traj\_k(time, traj) ;

 float traj\_lat(time, traj) ;

 float traj\_long(time, traj) ;

Example NCL scripts can be provided for plotting the trajectories on a map and for gathering frequency distributions upon request.

**Source Code**

The following files have been changed. Note that dyn\_em/solve\_em.F contains code for trajectories but it has not been modified.

Registry/ Registry.EM\_COMMON

share/solve\_interface.F

dyn\_em/module\_em.F

The following file has been added:

share/module\_trajectory.F

**wrfinput\_traj\_d01 example**

&traj\_default

traj\_def%start\_time = '2012-05-29\_12:10:00'

traj\_def%stop\_time = '2012-05-30\_03:00:00'

traj\_def%dyn\_name(1:8) = 'p', 'T', 'z', 'u', 'v', 'w', 'rainprod', 'evapprod'

traj\_def%hyd\_name(1:6) = 'QVAPOR', 'QCLOUD', 'QRAIN', 'QICE', 'QSNOW', 'QGRAUP'

traj\_def%chm\_name(1:10) = 'co', 'o3', 'no', 'no2', 'hcho', 'h2o2', 'ch3ooh', 'ho', 'ho2', 'ch3o2'

 /

 &traj\_spec

traj\_type(1)%start\_time = '2012-05-29\_23:10:30'

traj\_type(1)%stop\_time = '2012-05-30\_02:00:00'

traj\_type(1)%lon = -97.80

traj\_type(1)%lat = 35.85

traj\_type(1)%lev = 600.

traj\_type(2)%start\_time = '2012-05-29\_23:10:30'

traj\_type(2)%stop\_time = '2012-05-30\_02:00:00'

traj\_type(2)%lon = -97.70

traj\_type(2)%lat = 35.85

traj\_type(2)%lev = 600.

traj\_type(3)%start\_time = '2012-05-29\_23:10:30'

traj\_type(3)%stop\_time = '2012-05-30\_02:00:00'

traj\_type(3)%lon = -97.60

traj\_type(3)%lat = 35.85

traj\_type(3)%lev = 600.

/

For this example, there are 3 trajectories starting from different longitudes. In the WRF model namelist.input file, the following should be included.

&domains

num\_traj = 1000

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&physics

traj\_opt = 1,

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