Technical note – WRF-HYSPLIT coupling

December, 2015 (Prepared by Fantine)

- **Overview**

HYSPLIT, a Lagrangian dispersion model, has been coupled (inline) to the WRF-ARW meteorological model in such a way that the HYSPLIT calculation is run as part of the WRF-ARW prediction calculation. The inline system takes advantage of the high temporal frequency of WRF's variables (Table 1), as well as the elimination of temporal and vertical interpolation of meteorological data. The dispersion calculation uses the same vertical coordinate system as WRF, resulting in a more consistent depiction of the state of atmosphere and the dispersion simulation. The inline HYSPLIT includes dispersion, trajectory, deposition (dry and wet) and radioactive decay.

Table 1. List of WRF internal variables used in the inline HYSPLIT.

	Variable name used in WRF	Unit	Description
Static variables	LU_INDEX	24 Categories	Dominant land use category
	HGT	m	Terrain elevation
	ZNT	m	Roughness length
2D variables	Th2	deg-K	Potential temperature at 2-m
	PSFC	Pa	Surface pressure
	q2	kg kg^{-1}	Mixing ratio at 2-m
	uz10	m s^{-1}	u component of wind at ZNT
	vz10	m s^{-1}	v component of wind at ZNT
	PBLH	m	Boundary layer height
	UST	m s^{-1}	Friction velocity
	HFX	w m^{-2}	Sensible heat flux
	SWDOWN	w m^{-2}	Downward shortwave flux
	RAINCV+RAINNCV	mm/time-step	Time-step precipitation
	MU+MUB	Pa	Total dry air mass in colum
3D variables	P+PB	Pa	Total pressure
	T	deg-K	Potential temperature
	QVAPOR	kg kg^{-1}	Water vapor mixing ratio
	U	m s^{-1}	U component of wind
	V	m s^{-1}	V component of wind
	W	m s^{-1}	W component of wind
	PH+PHB	m^{-2} m^{-2}	Geopotential height

- **Model version**

The HYSPLIT model (version 4) was implemented into WRF v3.7.

- **Modified and added files in WRF**

  Makefile
  Registry/Registry.EM
  Registry/registry.hysplit
      – *including namelist parameters, dimensions, variable arrays and halo for HYSPLIT*
  share/mediation_integrate.F
      – *calling subroutines to read CONTROL and EMITIMES for HYSPLIT*
  dyn_em/solve_em.F
      – *calling HYSPLIT's main subroutine*
  /hysp
      – *directory for HYSPLIT related subroutines*
  README.hysplit
      – *description of namelist parameters for $hysplit*

- **Installation**

Run the "run.replace" script by providing the path of your WRF directory. This script copies modified and newly added files to your WRF directory. Clean up the model, configure and compile like installing a standard WRF.

- **Input and output files**

Input files for running WRF - wrfinput, wrfbdy
                                    wrffdda (optional for grid nudging)

Namelist files - CONTROL (same format as the standard HYSPLIT)
                EMITIMES (optional for HYSPLIT time varying emissions)
                namelist.input (including &hysplit section)
                addfields.txt (optional for running trajectory)

Output files
cdump - default binary HYSPLIT output concentration in lat/lon coordinate
wrfout - netcdf WRF output format including extra variables
        hycsum - *tracer concentration in WRF grid (not fully evaluated)*
        hyolat, hyolon, hyohgt - *lat/lon/height info of each particle*

- **Running the inline HYSPLIT**

For running the inline dispersion, set "run_hysplit" to 1 in the namelist.input and provide parameters to configure the dispersion calculation (refer to README.hysplit).

For running trajectory, set both "run_hysplit" and "run_traj" to 1 in the namelist.input. The namelist file should include the following line in $time_control that position information (lat/lon/height) of trajectory will be written out in wrfout files.

      iofields_filename   = "addfields.txt" (ex: +:h:0:HYOLAT,HYOLON,HYOHGT)

Execute "wrf.exe" like running a standard WRF simulation.

- **Details of the inline coupling**

The inline coupling occurs at WRF's computational loop where the required meteorological fields are transferred from the WRF model to HYSPLIT. The frequency of meteorological data transfer to HYSPLIT is in time intervals of minutes or even seconds depending on the user-defined time step in WRF. The inline HYSPLIT computes the transport and dispersion of Lagrangian particles in terms of the "eta" layers configured in WRF's vertical coordinate system.

The inline dispersion calculation can be run using WRF decomposed domains. All CPUs used for WRF's parallelization carry the Lagrangian particles information and concentrations. The CPU associated with the decomposed domain in which the particle is located will compute the transport and mixing of that particle. Communication between CPUs takes place when particles move from the current to the neighboring CPU, or at the output time step for the tracer concentrations.