HWRF Idealized Capability

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Overview of idealized capability

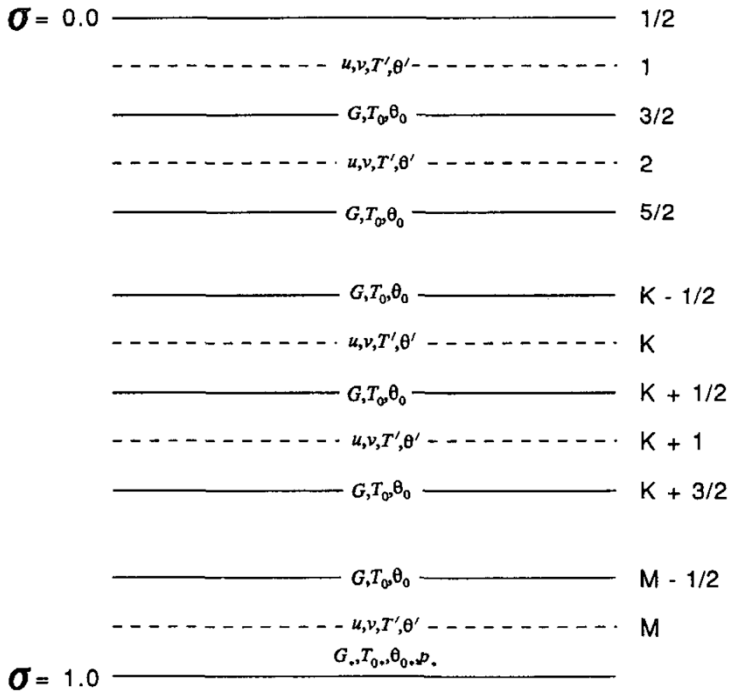
- Initialization uses a prescribed vortex superposed onto a quiescent environment. Default
  - Max intensity of 20 ms^{-1}
  - Radius of maximum winds (RMW) - 90 km
- The model configuration is same as the real run
  - Three domains with telescopic nests
- f- or β -plane
- Lower boundary is water (no land masses)
- Sea surface temperature
  - time-invariant (no ocean coupling)
  - horizontally homogeneous
  - default =302 K
- Uses: research and development

Wang, Y., 1995: An inverse balance equation in sigma coordinates for model initialization *Mon. Wea. Rev.*, **123**, 482–488.

Creation of the idealized vortex - I

The vortex is based on the balance equation relating prescribed wind fields to mass fields

- The atmosphere is divided into M layers in the sigma coordinate system.
- The initial background state temperature (T_o) along with a prescribed forcing term (G) in the balance equation are defined at the interfaces of the model layers.
- The initial vortex winds along with the temperature perturbation (T'), derived from the background state are defined at mid-levels levels between the interfaces.



Creation of the idealized vortex - II

- The wind field of the initial vortex is prescribed as σ in cylindrical polar coordinates by:

$$V(r,\sigma) = V_m\left(\frac{r}{r_m}\right)\sin\left(\frac{\pi\sigma}{2}\right)e^{\frac{[1-(r/r_m)]^b}{b}}$$

where V_m is the maximum wind at the surface, r_m is the radius of maximum wind, r is the radius from the vortex center, and $b = 1$.

- The forcing term in the balance equation is given by:

$$G(u,v) = 2J(u,v) + f\zeta - u\beta$$

where J is the Jacobian, f is the Coriolis parameter, ζ is the vorticity and β is the meridional gradient of the Coriolis parameter.

Creation of the idealized vortex - III

- The pressure at $\sigma = 1$ is obtained by solving the Poisson equation:

$$\nabla^2 \ln(p_*) = \frac{G_d}{RT_d^0}$$

where subscript d denotes the variable evaluated at $\sigma = 1$.

- The temperature perturbations at the rest of the sigma levels are determined by solving Poisson equation:

$$\nabla^2 T_k' = \nabla \cdot \left[\left(\frac{\partial T'}{\partial \ln(\sigma)} \right) \nabla \ln(p_*) \right] + \left[\left(\frac{\partial T_0}{\partial \ln(\sigma)} \right) \nabla^2 \ln(p_*) \right]_k - \left[\frac{\partial G}{R \partial \ln(\sigma)} \right]_k$$

- Finally, using the non-hydrostatic approximation, the geopotential heights are obtained from the total temperature and moisture fields.

Code and scripts

- WPS
  - geogrid, ungrib, metgrid, mod_levs
- No vortex initialization, data assimilation, or ocean
- WRF
  - Must compile HWRF with IDEAL_NMM_TC=1
    - Specifying `./compile nmm_tropical_cyclone` on the command line.
  - *wrf.exe, ideal.exe* (cannot use wrf.exe from real compilation)
- UPP and graphics
- Scripts
  - Do not use scripts or wrappers in hwrf-utilities to run WPS and WRF.
    - They use data assimilation and vortex initialization (not needed for idealized)
  - Just run executables (grogrid.exe, wrf.exe as any MPI program)
    - Some scripts will be provided in practical for submitting to batch system
  - Use the scripts and wrappers in hwrf-utilities to run UPP and graphics

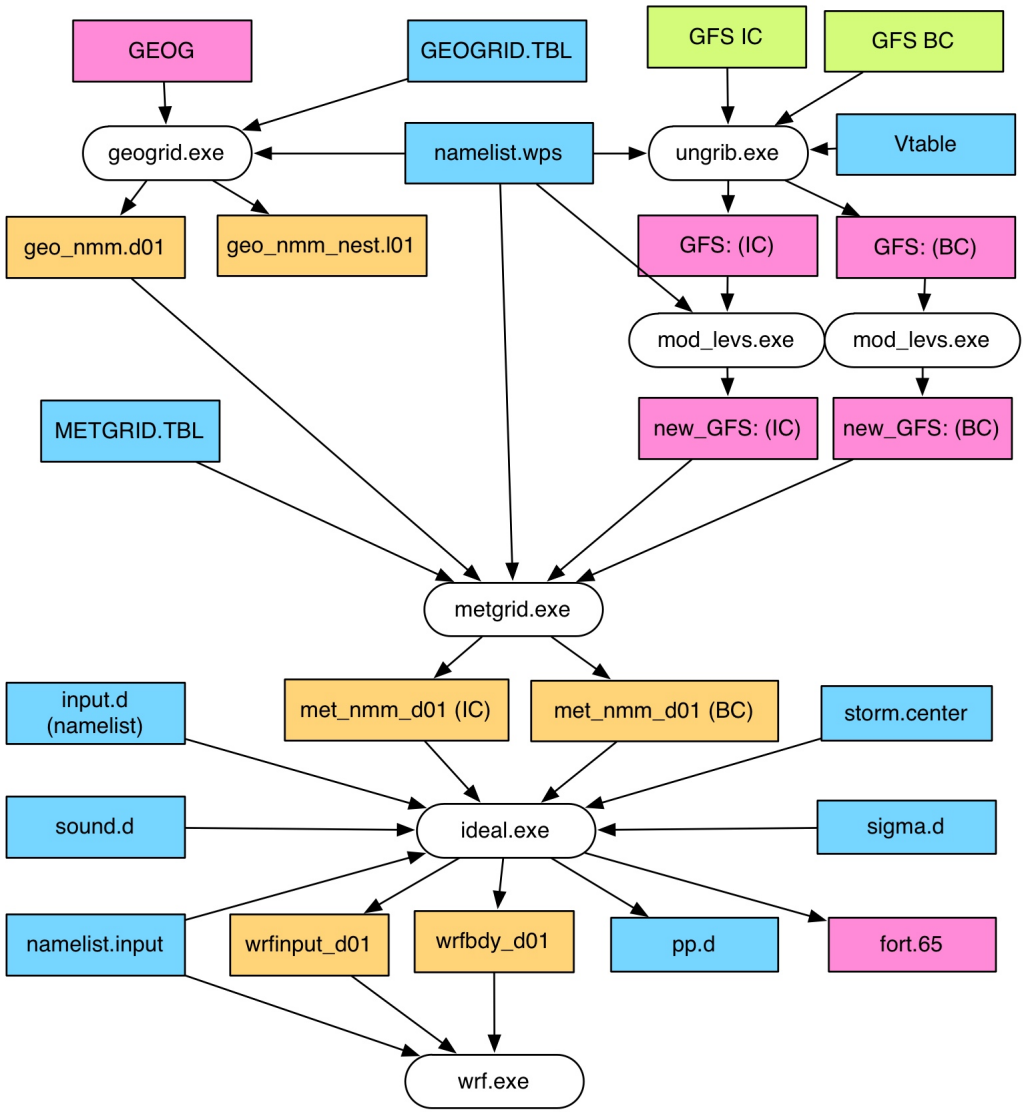
Input files

- Two GFS GRIB files to provide a template for IC and LBC
  - Files ***0825012000000*** and ***0825512000000***
- Files in *WRFV3_idealized/test/nmm_tropical_cyclone*.
  - Namelist file for WPS: ***namelist.wps***
  - Namelist file for WRF: ***namelist.input***
  - Vortex description file: ***input.d***
    - Intensity, RMW, f or β plane
  - Sounding data: ***sound.d***
    - 30 levels (or change number of levels in code)
  - Vortex center file: ***storm.center***
  - Sigma file: ***sigma.d***
    - Do not change this file
- Lookup tables for running WRF in *hwrf-utilities/parm*

Idealized model initialization

- Use WPS (*geogrid)* to setup domain
- Use WPS *(ungrib, mod_levs, and metgrid*) to process GFS for IC/LBC
  - *mod_levs is used* to reduce data in GFS file to expedite processing
  - Outputs are just a template to add the environment and vortex
- Use *ideal.exe* to create the actual IC and LBC (*wrfiput* and *wrfbdy*)
  - LBC are quiescent. This inevitably leads to some reflection when waves emanating from the vortex reach the outer domain boundaries

Flow Diagram for NMM Tropical Cyclone



Working directories

- Will need two working directories
  - *wpsprd* (for running WPS: geogrid, ungrib, mod_levs, metgrid)
  - *wrfprd* (for running ideal and wrf)
- Recommend the following structure (easier for the postprocessing and graphics scripts to find the files)
  - `cd ${SCRATCH}`
  - `mkdir –p HWRF_v3.5a/results/01I/2008090612/wpsprd`
  - `mkdir –p HWRF_v3.5a/results/01I/2008090612/wrfprd`
  - *In this presentation*
    - *workdir = ${SCRATCH}/HWRF_v3.5a/results/01I/2008090612*

Submitting to batch system

For practical session

geogrid.exe, ungrib.exe, mod_levs.exe, metgrid.exe, ideal.exe, wrf.exe

```
#!/bin/ksh
#BSUB –P AAAAAA          # project code
#BSUB -W 00:20           # wall-clock time (hrs:mins)
#BSUB -n $NPROC          # number of tasks in job
#BSUB -J myjob           # job name
#BSUB -o myjob.%J.out    # output file name in which %J is replaced by the job ID
#BSUB -e myjob.%J.err    # error file name in which %J is replaced by the job ID
#BSUB –q queue_name      # queue
#run the executable
mpirun.lsf $EXECUTABLE_NAME
```

Running geogrid

Enter the working directory

```
cd $workdir/wpsprd
```

Link the geogrid table

```
ln –fs  WPSV3/geogrid/GEOGRID.TBL.NMM ./GEOGRID.TBL
```

Copy the WPS namelist

```
cp WRFV3_idealized/test/nmm_tropical_cyclone/namelist.wps .
```

Edit *namelist.wps* set paths

```
geog_data_path = '/glade/p/ral/jnt/HWRF/datasets/wps_geog'
opt_geogrid_tbl_path = '.'
```

Run executable *geogrid.exe* on a compute node or batch system

```
bsub < bsub_geogrid
```

Verify that the output files were created

```
ls -l geo_nmm_nest.l01.nc geo_nmm.d01.nc
```

Running ungrib

Link the ungrib table

```
ln –fs  WPSV3/ungrib/Variable_Tables/Vtable.GFS  Vtable
```

Extract the two input GFS files and check if files are available

```
cp /glade/p/ral/jnt/HWRF/ideal_inputfiles/0825012000000 .
cp /glade/p/ral/jnt/HWRF/ideal_inputfiles/0825512000000 .
```

Link the GFS files to the names expected by ungrib

```
WPSV3/link_grib.csh 0825012000000 0825512000000
ls -l GRIBFILE.AAA GRIBFILE.AAB
```

Run *ungrib.exe* using script to submit it to batch queue

```
bsub < bsub_ungrib
```

Verify that the output files were created

```
ls -l GFS:2008-09-06_12 GFS:2008-09-11_12
```

Running mod_levls

Run mod_levs. Not MPI job, so does not require batch system

```
WPSV3/util/mod_levs.exe GFS:2008-09-06_12 new_GFS:2008-09-06_12
WPSV3/util/mod_levs.exe GFS:2008-09-11_12 new_GFS:2008-09-11_12
```

Verify that the output files were created

```
ls -l new_GFS:2008-09-06_12 new_GFS:2008-09-11_12
```

- Note: only the levels listed in variable *press_pa* in *namelist.wps* will be retained.

Running metgrid

Link the metgrid table

```
ln –fs  WPSV3/metgrid/METGRID.TBL.NMM ./METGRID.TBL
```

Edit *namelist.wps* set paths

```
opt_metgrid_tbl_path = = '.'
```

Run *metgrid.exe* using script to submit it to batch queue

```
bsub < bsub_metgrid
```

Verify that the output files were created

```
ls -l met_nmm.d01.2008-09-06_12:00:00.nc \
met_nmm.d01.2008-09-11_12:00:00.nc
```

Running ideal - I

Enter the working directory

```
cd $workdir/wrfprd
```

Link WRF input files

```
ln –fs hwrf-utilities/parm/hwrf_ETAMPNEW_DATA ETAMPNEW_DATA
ln –fs hwrf-utilities/parm/hwrf_GENPARM.TBL   GENPARM.TBL
ln –fs hwrf-utilities/parm/hwrf_LANDUSE.TBL   LANDUSE.TBL
ln –fs hwrf-utilities/parm/hwrf_SOILPARM.TBL  SOILPARM.TBL
ln –fs hwrf-utilities/parm/hwrf_VEGPARM.TBL   VEGPARM.TBL
ln –fs hwrf-utilities/parm/hwrf_tr49t67       tr49t67
ln –fs hwrf-utilities/parm/hwrf_tr49t85       tr49t85
ln –fs hwrf-utilities/parm/hwrf_tr67t85       tr67t85
```

Running ideal - II

Link the WPS files

```
ln -fs $workdir/wpsprd/met_nmm* .
ln -fs $workdir/wpsprd/geo_nmm* .
```

Copy namelist input

```
cp WRFV3_idealized/test/nmm_tropical_cyclone/namelist.input .
```

Running ideal - III

Copy the idealized simulation input files

```
cp WRFV3_idealized/test/nmm_tropical_cyclone/input.d .
cp WRFV3_idealized/test/nmm_tropical_cyclone/sigma.d .
cp WRFV3_idealized/test/nmm_tropical_cyclone/sound.d .
cp WRFV3_idealized/test/nmm_tropical_cyclone/storm.center .
```

Edit and modify files *input.d*, *sound.d*, if desired

File *storm.center* should not be altered (storm in center of inner nest)

File *sigma.d* should not be altered (vertical levels to create the initial vortex)

Run *ideal.exe* using script to submit it to batch queue

```
bsub < bsub_ideal
```

Verify that the output files were created

```
ls –l wrfinput_d01 wrfbdy_d01 fort.65
```

Running WRF

Run *wrf.exe* using script to submit it to batch queue

```
bsub < bsub_wrf
```

Verify that the output files were created

```
ls –l wrfout_d01* wrfout_d02* wrfout_d03*
```

Run UPP

```
cd hwrf-utilities/wrapper_scripts
```

Edit *global*_vars.ksh

```
export START_TIME=2008090612
export START_TIME_MINUS6=2008090606
export FCST_LENGTH=06
export FCST_INTERVAL=6
export STORM_NAME=IDEAL
export SID=01I
export BASIN=AL
export HWRF_SRC_DIR=${SCRATCH}/${USER}/HWRF/sorc
export HWRF_SCRIPTS=${HWRF_SRC_DIR}/hwrf-utilities/scripts
export HWRF_OUTPUT_DIR=${HWRF_SRC_DIR}/../results
export GRADS_BIN=/glade/p/jnt/ral/HWRF/bin
export GADDIR=/glade/apps/opt/grads/2.0.2/data/
```

Run *unipost_wrapper* using script to submit it to batch queue

```
cp  /glade/p/ral/jnt/HWRF/bin/bsub_Yellowstone_wrapper.ksh \
bsub_unipost_wrapper
```

Customize *bsub_unipost_wrapper*

```
bsub < bsub_unipost_wrapper

ls –l ${workdir}/postprd/*
```

Run Graphics

Stage the canned data (36-h previously done run)

```
cd ${SCRATCH}/${USER}/HWRF_v3.5a/
mkdir canned
cd canned
cp –R /glade/p/ral/jnt/HWRF/canned/01I .
cd hwrf-utilities/wrapper_scripts
```

Edit *global*_vars.ksh

```
export HWRF_OUTPUT_DIR=${HWRF_SRC_DIR}/../canned
export GRADS_BIN=/glade/p/ral/jnt/HWRF/bin
export GADDIR=/glade/apps/opt/grads/2.0.2/data
```

Run *rungrads_wrapper* using script to submit it to batch queue

```
cp  /glade/p/ral/jnt/HWRF/bin/bsub_Yellowstone_wrapper.ksh \
bsub_rungrads_wrapper
```

Customize bsub_rungrads_wrapper

```
bsub < bsub_rungrads_wrapper
ls –l ${workdir}/postprd/*gif
```