September 2013 Flood Simulation

1) Review test case directory for the Colorado Front Range.

```
cd ~/ClassMaterials/data/testcase/
ls
ls Run.Gridded
```

You will see a number of general file directories (FORCING, scripts) and a number of run directories (Run.Gridded, Run.Reach, Run.NWM). The general directories hold common files that get used by multiple runs, while the run directories hold files that are specific to a particular model configuration. This is just one way to setup your directory structure.

DOMAIN - contains all of the domain files needed for the Front Range domain runs. It includes the following files:

- Fulldom_hires.nc - (aka "routing stack") 2d file containing the high-resolution routing base grids (e.g., topography, flow direction, channels) as well as a few routing-specific parameters (LKSATFAC, OVROUGHRTFAC, RETDEPRTFAC).
- geo_em.nc - (aka "geogrid") 2d/3d file containing the LSM base grids (e.g., soil type, land use type, topography, green vegetation fraction).
- GEOGRID_LDASOUT_Spatial_Metadata.nc - contains the geospatial metadata (projection, coordinates) for the LSM grid; required if using the new nwmIo options.
- GWBUCKPARM.nc - 1d file containing the groundwater bucket model parameters for each catchment.
- HYDRO_TBL_2D.nc - 2d file containing the soil parameters used in the routing code (specific to overland and subsurface lateral routing).
- LAKEPARM.nc - 1d file containing the lake model parameters for each catchment.
- Route_Link.nc - 1d file containing the channel reach parameters (ComID, gage ID, bottom width, slope, roughness, order, etc.).
- soil_properties.nc - 2d/3d file containing the distributed soil and vegetation parameters used by NoahMP (saturated hydraulic conductivity, porosity, vegetation height, vegetation water use, etc.).
- spatialweights.nc - 1d file containing the mapping information between the catchments and the grids.
- wrfinput.nc - 2d file containing initialization information for the LSM (e.g., starting soil moisture and snow states); some (but not all!) of these variables are replaced when doing a "warm" start from a restart file.

FORCING - contains all of the atmospheric forcing files needed for an offline run. These files are of the format YYYYMMDDHH.LDASIN_DOMAIN[1-n] or YYYYMMDDHHMM.LDASIN_DOMAIN[1-n]. You can also include supplemental precipitation forcing files of the form YYYYMMDDHHMM.PRECIP_FORCING.nc.

RESTARTS (e.g., RESTART.2013091200_DOMAIN1, HYDRO_RST.2013-09-12_00:00_DOMAIN1) - LSM and hydro restart files pulled from a separate multi-year spinup; can use these to give the model a "warm" start.

2) Review Sept 2013 flood run directory and launch run.

This directory contains all the files necessary to conduct a particular run. Some of these might work as symlinks to the general directories discussed above. The run files include the domain files, forcing files, parameter tables, namelists, and executable binary.

```
cd Run.Gridded
ls -l
```

Review the namelists - one for NoahMP (namelist.hrldas) and one for the hydro routines (hydro.namelist):

```
vi namelist.hrldas
vi hydro.namelist
```

See the following links for detailed descriptions of the namelist options:
[namelist.hrldas]
[hydro.namelist]

Review the DOMAIN and FORCING directories:

```
ls DOMAIN
ls FORCING
```

Copy (or symlink) the recently compiled binary into the run directory:

```
cp ~/wrf_hydro_source/trunk/NDHMS/Run/wrf_hydro.exe .
```

To launch the run, type (this launch command will vary depending on your system and MPI libraries):

```
mpiexec -n 7 ./wrf_hydro.exe
```

3) **Use ncview to visualize outputs on high-resolution routing grid for the simulated 6-hr flood event (2013-09-12 0Z through 2013-09-12 6Z).**

```
ncview *.RTOUT_*
```

Select the `zwattablrt` variable to display. This is the depth to water table in the shallow (2-meter) soil column, so a value of 2 means there is no water table in the soil column and a value of 0 means the soil column is saturated to the surface.

Click `Bi-lin` to turn off smoothing (now you can see discrete pixels as the model sees them). Choose a sequential color scheme to more easily see low to high values: click the `3gauss` button to page through the built-in color schemes until you get to `ssec`. For this variable, 2 is "dry" and 0 is "wet", so we want to invert the color scheme. Do this by clicking the `Inv C` button. For some reason this inversion sets 0 (which should be bright orange) to black, so we'll change the range to -0.01 - 2. Click `Range` and change the minimum to -0.01. You can make the image bigger by clicking on the `MX4` (magnify) button.

Now scan through the time series. Use the ▶ button to flip through the timestamps. Now run through them all as an animation by clicking ▶▶. Use `Delay` to change the animation speed.

Do the same for the `sfcheadsubrt` variable. This is the surface head in mm (i.e., ponded water). For this variable you do not need to invert the color scheme since high is orange. Use the `Range` button to specify max values that show areas of "inundation".

4) Check land surface model output for same period.

```
ncview *.LDASOUT_*
```

Click through some of the output variables. For a description of the variables, see:
[WRF-Hydro Model Output Variables]

5) Explore the other 1d outputs at your leisure using ncview and NCO.

Some useful NCO commands to explore netcdf files.

- To view header information (metadata) about the netcdf file:
  `ncdump -h filename.nc`
- To get the mean of a variable:
  ```
  function ncavg { ncap2 -O -C -v -s "foo=${1}.avg();print(foo)"
  ${2} ~/foo.nc | cut -f 3- -d ' ' ; }
  Usage: ncavg $var_nm $fl_nm
  ```
- To get the max of a variable:
  ```
  function ncmax { ncap2 -O -C -v -s "foo=${1}.max();print(foo)"
  ${2} ~/foo.nc | cut -f 3- -d ' ' ; }
  Usage: ncmax $var_nm $fl_nm
  ```
- To get the min of a variable:
  ```
  function ncmin { ncap2 -O -C -v -s "foo=${1}.min();print(foo)"
  ${2} ~/foo.nc | cut -f 3- -d ' ' ; }
  Usage: ncmin $var_nm $fl_nm
  ```
- To generate a new file that is the difference between two files:
  `ncdiff file1 file2 file1_file2.nc`

6) The run you just completed used NLDAS-2 forcings processed through the NWM forcing engine and then subsetted to the Front Range domain. Now we try additional precipitation products.

Archive your current output:

```
mkdir OUTPUT_NLDAS
mv 20* OUTPUT_NLDAS/.
```

You will see one other forcing directory in the Front Range directory: `PRECIP_MPE`. This directory contains supplemental precipitation estimates regridded to the Front Range domain. To use these in the model, one easy method is to create symbolic links to the supplemental files:

```
cd ..
ls PRECIP_MPE
cd FORCING
ln -sf ../PRECIP_MPE/*PRECIP_FORCING* .
ls -l 20130912*
```

To activate the use of supplemental precipitation files, just edit namelist.hrldas to change `FORC_TYP` to 6. Now it will read the precipitation variable from the PRECIP_FORCING.nc files but will read all other atmospheric forcing fields from the LDASIN files.

```
cd ../run.Gridded
rm -r FORCING
ln -sf ../FORCING .
vi namelist.hrldas
```
<<-- Change to FORC_TYP = 6

After you save the namelist change, launch a new run:

```
mpiexec -n 7 ./wrf_hydro.exe
```

Review outputs and compare to the previous run.

7) Experiment with different routing options or model configurations.

Example 1: Turn off terrain routing

`vi hydro.namelist` <<-- Turn off terrain routing options: SUBRTSWCRT = 0 and OVRTSWCRT = 1

Example 2: Turn off the bucket model in favor of pass-through

`vi hydro.namelist` <<-- Change groundwater option from the exponential bucket model to a simple pass-through: GWBASESWCRT = 2

Example 3: Run a simulation as a cold-start

```
vi namelist.hrldas
```
<<-- Comment out the restart file entry: RESTART_FILENAME_REQUESTED

```
vi hydro.namelist
```

<<-- Comment out the restart file entry: RESTART_FILE

<<-- Tell the model to initialize the groundwater buckets from the GWBUCKPARM table (Zinit): GW_RESTART = 1

Execute model with gridded channel and compare results to previous runs.