Commands that might be useful:

- To view the values in a variable:
  - `ncdump -v variablename filename`
- To change the values in a variable based on a multiplier:
  - `ncap2 -O -s "parametername=parametername*0.5" filename filename`
- To change the values in a variable to a constant:
  - `ncap2 -O -s "parametername=parametername*0+1500.0" filename filename`
- To change the values in a variable based on values in another variable:
  - `ncap2 -O -s "where(param1==X) param2==Y" filename filename`
- Example shell script to loop through all files and modify a precip field:

```
for i in `ls 20*.LDASIN_DOMAIN1`; do
  ncap2 -O -s "RAINRATE=RAINRATE*1.25" ${i} ${i}
done
```

- Example python code to create timeseries of streamflow and plot:

```
%matplotlib inline
import xarray as xr
import matplotlib.pyplot as plt
import pandas as pd
from pandas.plotting import register_matplotlib_converters
register_matplotlib_converters()

chanobs_baseline =
xr.open_mfdataset('/home/docker/wrf-hydro-training/output/lesson5/run_gridded_baseline/
*CHANOBS*', combine='by_coords')
chanobs_exp =
xr.open_mfdataset('/home/docker/wrf-hydro-training/output/lesson5/run_no_terrain_routin
g/*CHANOBS*', combine='by_coords')

fig, axes = plt.subplots(ncols=1,figsize=(12, 6))
plt.suptitle('Hydrograph',fontsize=24)
chanobs_baseline.sel(feature_id = 2).streamflow.plot(label='Baseline',
                                                     color='black',
                                                      linestyle='--')
chanobs_exp.sel(feature_id = 2).streamflow.plot(label='Experiment',
                                                     color='red',
                                                     linestyle='-')

plt.ylim(0,50)
plt.legend()
plt.show()
```

- Example python code to create timeseries of domain-average LH (2d) and plot:

```
%matplotlib inline
import xarray as xr
import matplotlib.pyplot as plt
import pandas as pd
from pandas.plotting import register_matplotlib_converters
register_matplotlib_converters()

# Load the time series
ldasout_base =
xr.open_mfdataset('/home/docker/wrf-hydro-training/output/lesson5/run_gridded_baseline/
*.LDASOUT*', combine='by_coords')
```

```
ldasout_exp =
xr.open_mfdataset('/home/docker/wrf-hydro-training/output/lesson5/run_no_terrain_routin
g/*.LDASOUT*', combine='by_coords')

# Calculate the mean latent heat flux across the domain
et_base = ldasout_base.LH.mean(dim=('y','x'), skipna=True)
et_exp = ldasout_exp.LH.mean(dim=('y','x'), skipna=True)

# Plot the soil moisture time series
fig, axes = plt.subplots(ncols=1,figsize=(12, 6))
plt.suptitle('Average Latent Heat Flux',fontsize=24)
et_base.plot(label='Baseline', color='black', linestyle='--')
et_exp.plot(label='Experiment', color='blue', linestyle='-')
plt.legend()
plt.show()
```

WRF-Hydro Resources:
https://ral.ucar.edu/projects/wrf_hydro/technical-description-user-guide

User Guide:
https://ral.ucar.edu/sites/default/files/public/WRF-HydroV5TechnicalDescription_update512019_0.pdf
(see page 55 for forcing variables and Appendix 13 and 14 for parameter variable names/descriptions)

Reference Docs:
https://ral.ucar.edu/sites/default/files/public/WRF-Hydrohydro.namelistfiledescriptionofoptionsV5.pdf
https://ral.ucar.edu/sites/default/files/public/WRFHydroV5_OutputVariableMatrix_V5.pdf

NCO References:
http://nco.sourceforge.net/nco.html
http://research.jisao.washington.edu/data_sets/nco/

Domain File Key Variables:

DomainFile	Variable Name	Dimensions	Description	Units	Notes
geo_em.d01.nc	LU_INDEX	LSM grid	Land cover type	Categorical	Hydro routing code uses this variable to define land cover type. The classification scheme is determined by the global attribute MMINLU and ISURBAN, ISWATER, and ISOILWATER are used to define special types. See MPTABLE.TBL for NoahMP-supported land cover classification schemes.
	SCT_DOM	LSM grid	Dominant top layer soil texture class	Categorical	Hydro routing code uses this variable to define soil type (texture class). Currently there is only one texture class defined per cell (not variable with depth). See SOILPARM.TBL for the supported texture classes.
	HGT_M	LSM grid	Elevation	m	Not used by the model but useful for reference.

wrfinput.d01.nc	IVGTYP	LSM grid	Land cover type	Categorical	LSM uses this variable to define land cover type. The classification scheme is determined by the global attribute MMINLU and ISURBAN, ISWATER, and ISICE are used to define special types. See MPTABLE.TBL for NoahMP-supported land cover classification schemes.
	ISLTYP	LSM grid	Dominant top layer soil texture class	Categorical	LSM uses this variable to define soil type (texture class). Currently there is only one texture class defined per cell (not variable with depth). See SOILPARM.TBL for the supported texture classes.
	HGT	LSM grid	Elevation	m	Not used by the model but useful for reference.
	CANWAT	LSM grid	Initial canopy water storage	mm (kg/m2)	
	LAI	LSM grid	Initial LAI	m2/m2	Only used by certain NoahMP settings
	SEAICE	LSM grid	Presence of sea ice		
	SHDMAX	LSM grid	Maximum green vegetation fraction	% (0-100)	Only used by certain NoahMP settings
	SHDMIN	LSM grid	Minimum green vegetation fraction	% (0-100)	Only used by certain NoahMP settings
	SMOIS	LSM grid, soil layers	Volumetric soil moisture content	m3/m3	
	SNOW	LSM grid	Snow water equivalent	mm (kg/m2)	
	TMN	LSM grid	Constant deep soil temperature	K	
	TSK	LSM grid	Surface temperature	K	
	TSLB	LSM grid, soil layers	Soil temperature	K	
	XLAND	LSM grid	Land/water mask (1=land, 2=water)	categorical	
Fulldom_hires.nc	TOPOGRAPHY	Routing grid	Terrain grid or Digital Elevation Model (DEM).	m	
	FLOWDIRECTION	Routing grid	Flow direction grid, which explicitly defines flow directions along the channel network in gridded routing. This variable dictates where water flows into channels from the land surface as well as in the channel.	categorical	
	FLOWACC	Routing grid	Number of upstream cells that drain into each cell.	count	

	CHANNELGRID	Routing grid	Channel network grid identifying the location of stream channel grid cells (-9999=no channel, -1=deactivated channel, 0=active channel)	categorical	
	STREAMORDER	Routing grid	Strahler stream order grid identifying the stream order for all channel pixels within the channel network.	categorical	
	LKSATFAC	Routing grid	Multiplier on saturated hydraulic conductivity in lateral flow direction.	dimensionless	
	RETDEPRTFAC	Routing grid	Multiplier on maximum retention depth before flow is routed as overland flow.	dimensionless	
	OVROUGHRTFAC	Routing grid	Multiplier on Manning's roughness for overland flow.	dimensionless	
	frxst_pts	Routing grid	Prescribed forecast points	index	
	basn_msk	Routing grid	Prescribed basin masks	index	
	LAKEGRID	Routing grid	Prescribed lakes	index	
	landuse	Routing grid	Land use from geogrid regridded to the high-res routing grid	categorical	