**Fire Challenge:** Simulate a fire over the Pocono watershed and explore changes in streamflow response during the post-fire storm event.

Parameters to consider:

- LU_INDEX in geo_em.d01.nc and IVGTYP in wrfinput_d01.nc
  - See veg type descriptions at the top of MPTABLE.TBL. What is current land cover type and what might a post-fire type be?
  - What else should we manually change when we change land cover type? What do we get for "free"?
- OVROUGHRTFAC in Fulldom_hires.nc and OV_ROUGH2D in hydro2dtbl.nc
  - How do these parameters differ? Why is one a constant and one varies in space? What are the dimensions of each? See HYDRO.TBL as a reference.
  - Which direction would you modify this parameter (increase or decrease)? What is a reasonable post-fire value?
- refkdt in soil_properties.nc
  - Lookup details on this infiltration parameter. Which direction should you change the values (higher or lower)?

BONUS: Try doing parameter modifications based on starting land cover type or elevation to mimic different burn intensities.

BONUS: Consider a few additional parameters

- RETDEPRTFAC in Fulldom_hires.nc
  - Lookup details on this retention depth parameter. Which direction should you change the values (higher or lower)?
- LAI & PAI, HVT & HVB, NROOT in MPTABLE.TBL (note that some of these are also in soil_properties.nc)

**Fire Challenge**: Step-by-Step Guide

1. Compile the code with spatial soil and debug on
2. Setup a new run directory with the Gridded or Gridded_no_lakes test case
3. Change vegtype across the full domain to barren
    a. See LU_INDEX in geo_em.d01.nc and IVGTYP in wrfinput.d01.nc
    b. See MPTABLE.TBL to determine what the land cover types are
    c. Use the ncap2 command
    d. BONUS: Change only the forest type to barren (use the ncap2 command with a where clause).
4. Run the model
5. Use Python and xarray to plot the streamflow timeseries at forecast point 2 (above the reservoir). Are there big differences?
    a. NOTE: If running with spatial soil active, changing the land cover type ONLY impacts variables that are pulled from lookup tables (those that are in MPTABLE.TBL but not in soil_properties.nc).
    b. BONUS: Redo the experiment above but with spatial soil compile-time option turned OFF. You will also want to specify a new name for hydro2dtbl.nc to let the model create a new version based on your new land cover map.
6. Change the overland roughness to a smaller value to approximate post-fire litter removal and soil crusts.
    a. See OV_ROUGH2D in hydro2dtbl.nc OR OVROUGHRTFAC in Fulldom_hires.nc
    b. Use HYDRO.TBL to review default overland roughness values for different land cover types to select an appropriate one for post-fire.
    c. BONUS: Vary the OVROUGHRTFAC based on elevation or land cover type as a proxy for burn intensity.
7. Run the model
8. Use Python and xarray to plot the streamflow timeseries at forecast point 2 (above the reservoir). Are there big differences?
9. Change the infiltration scaling parameter to account for post-fire hydrophobicity.
    a. See refkdt in soil_properties.nc (note that a higher value encourages more infiltration and less surface runoff, and a lower value encourages less infiltration and more surface runoff)
10. Run the model
11. Use Python and xarray to plot the streamflow timeseries at forecast point 2 (above the reservoir). Are there big differences?

**Initial Condition Challenge:** Evaluate the Pocono watershed event sensitivity to initial soil moisture conditions. Run simulations with initial soil moisture set to high, medium, and low values and plot differences in streamflow response to the event.

Parameters to consider:

- smcmax, smcref, smcwlt in soil_properties.nc
    - What do these parameters represent? Are they constant or do they vary in space?
    - Based on these values, what are reasonable high, medium, and low soil moisture state values?
- smc1, smc2, smc3, smc4 and sh2ox1, sh2ox2, sh2ox3, sh2ox4 in HYDRO_RST
    - What do the 1-4 variables represent?
    - What do these two different sets of states represent and how do they differ?

BONUS: Run that same initial condition experiments but with other hydrologic states.

**Initial Condition Challenge:** Step-by-Step Guide

1. Compile the code with spatial soil and debug on.
2. Setup a new run directory with the Gridded or Gridded_no_lakes test case.
3. Examine the soil texture classes in your domain.
4. Examine the values for smcmax (porosity), smcref (field capacity), and smcwlt (wilting point) in soil_properties. Alternatively, look at SOILPARM.TBL and check the values there for the soil texture classes in your domain.
5. Examine the initial total soil moisture (smc) and liquid soil moisture (sh2ox) in the HYDRO_RST file.
    a. Why are there 4 different variables for these states?
    b. Do smc and sh2ox differ? Under what conditions would they differ?
6. Decide on reasonable high, medium, and low soil moisture state values to use for your experiments.
7. Copy the template run directory to create a high soil moisture initial condition run directory.
8. Modify the HYDRO_RST variable values for smc1-4 and sh2ox1-4 to match your high value.
9. Run the model.
10. Copy the template run directory to create a medium soil moisture initial condition run directory.
11. Modify the HYDRO_RST variable values for smc1-4 and sh2ox1-4 to match your middle value.
12. Run the model.
13. Copy the template run directory to create a low soil moisture initial condition run directory.
14. Modify the HYDRO_RST variable values for smc1-4 and sh2ox1-4 to match your low value.
15. Run the model.
16. Use Python and xarray to plot the streamflow timeseries at forecast point 2 (above the reservoir). Can you explain the differences in behavior?

**Forcing Uncertainty Challenge:** Evaluate precipitation uncertainty impacts on hydrologic response in the Pocono watershed during Hurricane Irene.

Variables to consider:

- Input variable RAINRATE in LDASIN files
- Output variables streamflow, latent heat flux, soil moisture, and groundwater
    - Does the precipitation variability linearly impact the water states and fluxes?
    - Which components of the water budget are most impacted?

BONUS: Experiment with different forcing variables (e.g., temperature, wind). Do these matter for the water budget components?

**Forcing Uncertainty Challenge:** Step-by-Step Guide

1. Compile the code with spatial soil and debug on
2. Setup a new template run directory with the Gridded or Gridded_no_lakes test case
3. Examine RAINRATE values at a few points in time over the event.
4. Decide on what you think a reasonable uncertainty bounds for precipitation inputs (e.g., + or - 10%? 25% 50%).
5. Copy the template run directory to create a high precipitation run directory.
6. Use the provided bash code to run a for loop over all of the LDASIN files and modify the RAINRATE variable.
7. Run the model.
8. Copy the template run directory to create a low precipitation run directory.
9. Use the provided bash code to run a for loop over all of the LDASIN files and modify the RAINRATE variable.
10. Run the model.
11. Use Python and xarray to plot the streamflow timeseries at forecast point 2 (above the reservoir). Can you explain the differences in behavior?
    a. Are the streamflow responses scaled linearly with the precip changes?
12. Use Python and xarray to plot other water budget components, such as evapotranspiration (or latent heat flux, LH in LDASOUT), soil moisture (SOIL_M in LDASOUT), and groundwater "bucket" levels (depth in GWOUT).
    a. Which states and fluxes are impacted more or less by the precipitation changes?
13. BONUS: Repeat the above but with other forcing (LDASIN) variables.