**Procedure for Running SALUS for the Midwest**

By Lydia Rill

Updated 01/25/17

**Goal:** Run SALUS for the Midwest (IA, IL, IN, MI, MN, MO, OH, SD, WI) for 1979-2016

**Sources of data:**

* Weather: Phase 2 of the North American Land Data Assimilation System (NLDAS-2) for 1979-2016 at a 1/8th-degree (~12.5 km) grid spacing
  + The hourly NLDAS data was aggregated into daily maximum temperature, minimum temperature, cumulative precipitation, and total solar radiation for this project.
  + <http://ldas.gsfc.nasa.gov/nldas/>
* Location of corn production: NASS Cropscape rasters of crop production for 2010-2015
  + (<https://nassgeodata.gmu.edu/CropScape/>)
* Soils: USDA SSURGO shapefiles by county, combined into statewide shapefiles
  + <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>
  + <https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>

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# Pre-processing Files

**Goal:** Determine the combinations of Mukey Soil and Weather Grid Point for the Midwest that will be used to run SALUS.

**Note:** Following Benjamin’s procedure, described in AgEco/Users/bdumont/CSCAP Procedure Whole Midwest.docx

**Scripts to use:** (Contain user set parameters. Spatial Analyst Extension is required. Need to be run within ArcGIS. Located within /Users/rilllydi/MidwestSALUS/Scripts/)

1. ExtractByAttribute.py
2. MosaicYears.py
3. ExtractByMask.py
4. SplitRaster.py
5. ExtractRaster\_final.R (R script)
6. FormatWx.py
7. **Copy CDL data to AgEco/Users/rilllydi/MidwestSALUS/CDL** 
   1. Ben’s CDLs:
      1. All Crops: Located in AgEco/Users/bdumont/CSCAP\_project\_GregMachine/CSCAP GIS/CDL/States\_All\_Crops/9 State/
      2. Corn Only: Located in AgEco/Users/bdumont/CSCAP\_project\_GregMachine/CSCAP GIS/CDL/States\_Corn\_Only/Midwest\_Corn\_Only
   2. Downloaded the CDL layers (NASS cropscape) for 2014 and 2015
      1. The files are 30m rasters, downloaded as .tif files for 9 states IL, IN, IA, MI, WI, MO, MN, OH and SD. (<https://nassgeodata.gmu.edu/CropScape/>)
8. **Process CDL data**
   1. Merged the states to a region for each year (2014 and 2015). (ProcessCDL)
      1. Input rasters to already existing raster in different directory (e.g. a copy of one of the rasters) using the MOSAIC tool. Use 0 value for Background and No Data!
         1. Output located in AgEco/Users/rilllydi/MidwestSALUS/CDL/IndivYears/Region
         2. Note projected coordinate system is custom Albers Conic Equal Area
   2. Combined years 2010-2015 to find all the locations where specific crops have been grown in the past 6 years
      1. Note: should only do this for specific crops, not all crops. Because otherwise some crops may mask out others if you wanted to extract specific crops later
      2. **Use rilllydi/MidwestSALUS/Scripts/ExtractByAttribute.py (20-25 min to loop through the 6 shapefiles)**
         1. Ben classified corn crops as: Corn, Dbl Crop Barley/Corn, Dbl Crop Corn/Soybeans, Dbl Crop Oats/Corn, AND Dbl Crop WinWht/Corn
         2. "CLASS\_NAME" = 'Corn' OR "CLASS\_NAME" = 'Dbl Crop Barley/Corn' OR "CLASS\_NAME" = 'Dbl Crop Corn/Soybeans' OR "CLASS\_NAME" = 'Dbl Crop Oats/Corn' OR "CLASS\_NAME" = 'Dbl Crop WinWht/Corn'
            1. *OR "CLASS\_NAME" LIKE '%Corn%'? But that will include Sweet Corn and “Pop or Orn Corn”*
         3. Output located in AgEco/Users/rilllydi/MidwestSALUS/CDL/IndivYears/Region/
      3. **Use rilllydi/MidwestSALUS/Scripts/MosaicYears.py**
         1. Mosaics the years 2010-2015 together to determine all location where the selected crop has been grown during at least 1 of the years.
         2. Then reclassifies all the attributes selected (types of the crop) as a value of 1.
         3. Output located in AgEco/Users/rilllydi/MidwestSALUS/CDL/Years2010-15/Region/
9. **Copy Soil data to AgEco/Users/rilllydi/MidwestSALUS/Soils**
   1. Ben’s Soil Rasters
      1. Located in Data2Plot/Source/mi\_soil\_init
      2. He converted the soil polygons into 30 m resolution raster, keeping the soil type with the largest area to represent the pixel
      3. I added a field (STMUKEY). Use field calculator and add the state abbreviation before the MUKEY (e.g. IA402176), using the Python code (‘IA’ + !MUKEY!)
      4. I converted the raster datasets to Albers Conic Equal Area (output named as “state\_soils\_A”)
   2. Note that I am keeping these soil raster datasets separated by state instead of mosaicking to one region because they are too large (it was taking 1.5+ hours)
   3. Downloaded SSURGO county soil polygons.
   4. Converted the county shapefiles from WGS84 to NAD83 (labelled 5070 for the epsg code). (fast in QGIS, script: ReprojectPoly.py)
   5. Convert the county shapefiles into 30m res rasters (arcpy script RasterizeSoil.py)
   6. Mosaic chunks of the county polygons (states are about 4-5 chunks) using arcpy scrip MosaicRaster.py
      1. THEN TRY GIVING TO HPC WITHOUT GIANT MEMORY ISSUES
   7. Use this updated?? Soil data for the analysis
10. **CDL x Soil**
    1. **Use rilllydi/MidwestSALUS/Scripts/ExtractByMask.py**
       1. Extract by Mask (where mask is the cdl\_*crop*1). This gives you a soil raster only for the locations where the specific crop is grown
       2. Projects the raster to WGS84 (1-2 min per state)
    2. **Use rilllydi/MidwestSALUS/Scripts/SplitRaster.py**
       1. Splits the state rasters into 9 tiles (9 is arbitrary).
       2. Output is multiple smaller rasters, shapefiles, and csv files located in AgEco/Users/rilllydi/MidwestSALUS/Soils\_in\_CDL/States/CornOnly/*state*\_split/
       3. This method was used to speed up processing.
11. **Determine nearest weather grid for each crop/soil pixel**
    1. Determine nearest weather grid for each crop/soil pixel and the unique combinations of soils and weather grid points.
       1. Info on NLDAS grid:
          1. Latitude starts at 25.0625° and Longitude starts at -124.9375° (lower left corner). Opposite corner is 52.9375, -67.0625
          2. The grid boxes are at a 0.125° step, with 224 steps in the latitude and 464 in longitude
    2. **Use R script rilllydi/MidwestSALUS/Scripts/ExtractRaster\_final.R**
       1. Need to have R downloaded.
       2. **Now I can just use the baseline rasters! And extract the soils and weather from there! TRYING THIS TO SEE IF THERE WILL BE LESS GAPS. Use ExtractSoilWx.R**
    3. **Use rilllydi/MidwestSALUS/Scripts/FormatWx.py**
       1. Weather coordinates and the associated MUKEYs (soil types) so each row will be input to SALUS which will run all the soils for one weather file at a time (<state>\_wx\_soil\_unique\_SALUS.csv)
       2. Output located in AgEco/Users/rilllydi/MidwestSALUS/Wx\_For\_Soils for each state.

# SALUS Parameters

* Used the script MakeBatch\_Midwest\_HPC.py (a copy is located within Users/rilllydi/MidwestSALUS/Scripts/Backup\_MakeBatch\_HPC/)
* Use AllMakeBatch\_HPC.sh to run all the MakeBatch programs
  + There are 7 different scenarios which are described below.
  + This script creates the .bat, .sh, .sdb.xml, and .xdb.xml files needed to run SALUS. Additionally the weather (.wdb.xml) files are needed to run SALUS.
  + This script creates the files so that 99 jobs are run on the HPC (11 jobs per state). The jobs contain 1/11 of all the weather grids in the state and their associated MUKEYS.
  + Note that the memory and time may need to be changed
  + Note that I would run the MakeBatch\_SC1.py (through AllMakeBatch.sh) in /Volumes/WebData/MidwestSALUS in order to zip the weather files for each state chunk. (Then copy the zipped wx files to the HPC).
    - The extra code:

import tarfile

# Zip the weather files

WxZip = rootdir + "config/" + st + "\_" + str(chunk) + "\_weather.tar.gz"

if os.path.isfile(WxZip):

os.remove(WxZip)

WxZipOut = tarfile.open(WxZip, mode='w:gz')

wxdir = rootdir + "Weather/"

wxdir = "/Volumes/WebData/MidwestSALUS/Weather/"

for Weather in WthIDList[i:j]:

WFile = Weather + ".wdb.xml"

FullWFile = wxdir + WFile

morewx = open("/Volumes/WebData/MidwestSALUS/morewx.txt",'a')

if ( not os.path.isfile(FullWFile) ):

Weather = Weather.replace("N\_",",-")

Weather = Weather.replace("W","")

print(Weather)

morewx.write(Weather + "\n")

else:

WxZipOut.add(FullWFile, arcname=WFile)

* To run on the HPC you need to run AllMakeBatch\_HPC.sh like mentioned above. Then you need to check the permissions on the allsub.bat (chmod 744 allsub.bat) and run it ./allsub.bat
* Parameters for SALUS:
  + Irrigation : no
  + Crop Planting Dates: When 50% of the crop was planted according to the 5 year average (2011-2015) by state

(<https://quickstats.nass.usda.gov/#615EC63B-9669-333B-9E8C-87A4C8BDFD4A>) – crops, field crops, (corn, soybean, or winter wheat), progress, 5 year avg, measured in pct planted, state, 2015

(calculated by taking the linear trend between 1 point above and 1 below 50%, as the entire trend was not ­very linear)

Data located in excel files under MidwestSALUS/SALUS\_Parameters/

* + Winter Wheat planting dates not available for Iowa, Minnesota, and Wisconsin so Benjamin’s dates were used.

|  |  |  |  |
| --- | --- | --- | --- |
| **State** | **Soybean Planting DOY** | **Corn Planting DOY** | **Winter Wheat Planting DOY** |
| IA | 138 | 126 | 281 |
| IL | 142 | 124 | 289 |
| IN | 142 | 129 | 290 |
| MI | 145 | 134 | 282 |
| MN | 142 | 130 | 281 |
| MO | 148 | 120 | 297 |
| OH | 145 | 132 | 288 |
| SD | 145 | 132 | 267 |
| WI | 146 | 136 | 279 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **General Crop Type Parameters for SALUS** | | | | | | | |
| **Crop** | **CropMod** | **SpeciesID** | **Cultivar** | **Ppop** | **Ppoe** | **RowSpc** | **Fertilizer** |
| Corn | C | MZ | MZH | 8 | 8 | 75 | Yes |
| Rye | S | RY |  | 250 | 250 | 15 |  |
| Soybean | S | SB |  | 40 | 40 | 50 |  |
| Wheat | C | WH | IB1015 (Benjamin used IB1111-not available) | 250 | 250 | 15 | Yes |
| Clover | S | CL |  | 250 | 250 | 15 |  |

|  |  |  |
| --- | --- | --- |
| **Planting and Harvesting Dates** | | |
| **Crop Component** | **Planting DOY** | **Harvest DOY** |
| Maize | Varies by state | 300 |
| Rye | 308 | 20 days before next crop (Benjamin used DOY 70) |
| Soybean | Varies by state | 300 or 20 days before Winter Wheat |
| Winter Wheat | Varies by state | 223 |
| Clover (Ben used Rye) | 244 | 20 days before next crop |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SALUS Parameters for Multiple Scenarios** | | | | |
| **Scenario** | **Rotation** | **Manure** | **N Fertilization** | **Tillage** |
| SC1 | Continuous Corn *(CCLev = “no”)* | Yes, Fall *(10000 kg/ha, RE003-barnyard, DOY 315)* | 200kgN/ha at planting (inorg) | conventional |
| SC2 | Continuous Corn *(CCLev = “no”)* | No | 200kgN/ha at planting (inorg) | conventional |
| SC3 | Continuous Corn *(CCLev = “no”)* | No | 50-150kgN/ha at Plt – V6 (inorg) *- 50 at planting date, 150 at 35 days after planting* | conventional |
| SC4 | Continuous Corn *(CCLev = “no”)* | No | 50-150kgN/ha at Plt – V6 (inorg) *- 50 at planting date, 150 at 35 days after planting* | None |
| SC5 | Continuous Corn + CC *(CCLev = “yes”)* | No | 50-150kgN/ha at Plt – V6 (inorg) *- 50 at planting date, 150 at 35 days after planting for Corn* | None |
| SC6 | Corn/SB + CC *(CCLev = “yes”)* (Corn *(year 1), Rye (year 1-year 2), Soybean (year 2), Rye (year 2-year 3))* | Yes, Fall *(10000 kg/ha, RE003-barnyard ,2 days before planting Rye)* | 50-150kgN/ha at Plt – V6 (inorg) *- 50 at planting date, 150 at 35 days after planting for Corn* | Only for cover crops with a depth of 22 |
| SC7 | Corn/SB/WW + CC  *(CCLev = “yes”) (Corn (year 1), Rye (year 1-year 2), Soybean (year 2), Winter Wheat (year 2-year 3), Clover (year 3))(Ben used Rye for last crop)* | Yes, Fall *(10000 kg/ha, RE003-barnyard, 2 days before planting Rye)* | 50-150kgN/ha at Plt – V6 (inorg) *- 50 at planting date, 150 at 35 days after planting for Corn,*  *G50 at planting and 150 at planting date minus 170 days for Winter Wheat* | Only for cover crops with a depth of 22 |

* + Additional Parameters that do not change between scenarios:
    - Planting Parameters
      * For Maize only: SDepth = 4 (Planting Depth in cm)
      * All other crops: SDepth = 3 (Planting Depth in cm)
    - Fertilizer Parameters
      * IFType = FE001 (Ammonium nitrate)
      * FerCode = AP001 (Broadcast, not incorporated)
      * FINP = 100 (Incorporation percentage)
      * DFert = 5 (Application depth in cm)
      * FerDecRt = 1 (Fertilizer decomposition rate)
    - Conventional Tillage Parameters (if tillage is used)
      * Tillage the day before planting
      * TImpl = TI005 (Moldboard plow)
      * TDep = 30 (Tillage depth in cm)
    - Harvest Management Parameters
      * HBPc = 0 (Percent of byproduct harvested)
      * Maize, soybean, or wheat:
        + HPc = 100 (Harvest percentage)
        + HCom = H (Harvest component code: H for Harvest Product, C for Canopy)
        + HKnDnPc = 100 (Harvest knock-down percent)
      * Rye or clover:
        + HPc = 0 (Harvest percentage)
        + HCom = C (Harvest component code: H for Harvest Product, C for Canopy)
        + HKnDnPc = 100 (Harvest knock-down percent)
    - Residue (Manure) Parameters
      * Residue 2 days before planting unless Fall application (DOY 315)
      * ResCode = RE003 (Barnyard manure)
      * Residue = 10000 (Amount, dry wt. kg/ha)
      * RINP = 90 (Incorporation percentage)
      * DepRes = 20 (Incorporation depth in cm)
      * ResC = 80 (C content of residues, dry wt. percentage) (Benjamin used 40)
      * ResN = 4 (N content of residues, dry wt. percentage) (Benjamin used 1)

### Future Climate Parameters

RCPs 2.6 and 6.0

* Environment modifications within the xdb files are used, instead of creating individual weather files.
* Benjamin used general parameters of RCPs 2.6 and 6.0 (shown in the following table)
  + For sensitivity analysis?
* **Check the AllMakeBatch.sh to see the parameters**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Baseline** | 1979-2015 NLDAS 2 Reanalysis Data | | | | | |
|  | **Variable** | **DJF** | **MAM** | **JJA** | **SON** | **Comment** |
| **RCP 2.6** | Precipitation | 1.1 | 1.1 | 0.95 | 1 | Multiplicative ratio |
| Temperature | +3 °C | | | | Added |
| CO2 | 400 ppm | | | | Replaced |
| **RCP 6.0** | Precipitation | 1.2 | 1.2 | 0.90 | 1 | Multiplicative ratio |
| Temperature | +6 °C | | | | Added |
| CO2 | 540 ppm | | | | Replaced |

# Processing SALUS Results

* The percentage of area of missing data due to missing SSURGO Mukey characteristics were calculated by state and the whole Midwest using the python script MissingSoilArea.py
  + Note that before this script was run the MakeBatch\_SC1.py file on the salusmodel server was appended so it wrote out the missing MUKEYs. Need to put this on the server?.
  + Then in ArcGIS an area field was added to the raster attribute tables for the (Soil/CDL) state-wide raster datasets which was easily calculated due to the 30m resolution (MU\_Area = Count \* 900). Then the attribute tables were exported at text files (note the format had to be fixed in excel, convert to numbers and remove empty column)
  + Then the python script was run, giving the following results.

|  |  |
| --- | --- |
| **State** | **Percent\_Missing\_Area** |
| wi | 0.05% |
| mi | 0.02% |
| oh | 0.58% |
| sd | 1.33% |
| mn | 0.01% |
| mo | 1.00% |
| il | 0.82% |
| in | 0.85% |
| ia | 0.59% |
| **Midwest** | **0.62%** |

* **Used the script Process\_Results\_Midwest.py** (located under /mnt/home/rilllydi/Results on the HPC)
  + This script reads in the SALUS seasonal output for the chunks and states and joins it together using the pandas library in python
  + Seasonal variables:
  + Calculates the seasonal average, min, and max of all the variables over the 38 years. (Results/Summary\_1979\_2016/).
  + The last value in 2016 for each of the variables is written out to a file (Results/End\_of\_2016/).
  + The script also writes out the yearly GWAD to a separate file (Results/Yearly\_1979\_2016/).
  + Total Output is csv files: 1 with 38 year averages, 1 for the last values, 1 for yearly (GWAD) for each of the 7 scenarios. (total of 3\*7 = 21 files)
  + Other variations (byState, by chunk are in github)
* Created the baseline rasters which contained attributes of MUKEY and the Weather ID coordinates (wxID\_y and wxID\_x) (ONLY NEED TO DO THIS ONCE)
  + **Used the script** **MakeBatch\_Baseline.py**  (located under /mnt/home/rilllydi/Results/ShellScripts/ on the HPC)
    - Creates the shell scripts to create the raster baselines using **MidwestRaster\_base.R** (located under /mnt/home/rilllydi/Results/ on the HPC)
      * This script overlays each pixel location of a soil type in the state with the state NLDAS weather grid polygon and then writes the coordinates as a raster.
    - Run ./allsubBase.bat to create the baseline rasters (Takes a long time!)
    - *IL\_1 looks fine. Trying IL\_1 and IL\_2. I wonder if binding the attribute tables is bad if there are multiple Values???- this should be unique!*
      * *IL\_2 looks good but IL\_1 got messed up! IL\_1 got assigned the values from IL\_2*
      * *If I write them out individually they are ok! You could do this at the state level on the HPC? Lots of memory?* 
        + *Try mosaicking the rasters and maybe R takes the vat automatically? Nope. I’d have to mosaic and then…?*
  + Used ArcGIS to manually mosaic these rasters together to the Midwest (takes ~11 min) (mosaic to existing raster and specify no data as -32768 and convert 1 bit to 8 bit. If there are weird holes, like in MN try using a copy of the MN base as the existing raster and mosaic all state bases to that. May need to do this multiple times before it works?)
* Instead of joining tables in R, try joining using ArcPy so maybe you don’t get those weird zero values everywhere?
* ADD a KEY WITH MUKEY AND WEATHER ID ON MOSAICED MIDWEST RASTER
  + MUKEY\_WxY\_WXX (no N OR W)
* **Used the script** **MakeBatch\_JoinRasterResults.py** (located under /mnt/home/rilllydi/Results/ShellScripts/ on the HPC)
  + Creates the shell scripts to join the raster baseline with the SALUS results through the attribute table of the raster
    - Calls the script **JoinMidwestRaster.R** (located under /mnt/home/rilllydi/Results/ on the HPC)
  + ./allsubJoinRasterResults.bat
* **Final Raster Results are found under Midwest\_Rasters. The names of the rasters should indicate the type of results.**

**Potential problems: soil type 399340,** 447564 (The source is soilmu\_a\_ia091, Spatialver 6, MUSYM of 507), IA 405718 whole county is missing no data…well not all but arcgis makes it look like that!

ArcGIS sets NA values to 0 automatically?

Try a different mosaic? (the baseline rasters look ok!)

Try a different intersect between NLDAS grid and the coordinates? Try a spatial points data frame… I think it’s not correct now… display the symbology using wxID\_y and it’s not good

Check THE WEATHER ID IS WRONG!!!!!!!!!!

* **GET SSURGO SCRIPTS FROM MAC**

1. **Trying projecting my soil shapefiles to NAD 1983 (m) (5070 epsg) already on the mac!**
2. **Convert to raster 30m res**
3. **Intersect with the corn raster**
4. **Upload to the HPC and try to intersect with weather**
5. **Also try splitting into 4 pieces and intersecting with weather and then mosaic in arcgis on desktop**

HPC:

These are necessary commands to load the libraries I want for R:

module load GNU/4.4.5  
module load OpenMPI/1.4.3  
module load R/3.2.0  
module load GEOS  
module load GDAL

Do this once:  
mkdir -p ~/R/library % if you have not yet done this before

Install the libraries you need:  
Rscript -e "install.packages('rgeos', lib='~/R/library',  
contriburl=contrib.url('<http://cran.r-project.org/')>)"

Do this command every time!

export R\_LIBS\_USER=~/R/library

* Need a script to create maps for each of the variables in a Midwest raster (CRmapper.mxd)
  + Light gray county boundaries
  + Cant change symbology type!! Must have it set before in the layer file….
    - Write out layer files for each input raster (not each variable yet)
  + Benjamin used NAD\_1983\_Albers data frame (curved maps) vs. WGS84 is flat

CREATE GITHUB REPO

# Folder and File Structure on the Server

**On the AgEco server under Users/rilllydi/MidwestSALUS**

Note that all years besides 2014 and 2015 were copied from bdumont server.

Note that all soils rasters were coped from bdumont server.

CDL/IndivYears

* States
  + AllCrops
    - *The CDL files for all crops by state downloaded from NASS CropScape for 2010 through 2015*
* Region
  + AllCrops
    - *The CDL files for all crops for the Midwest Region (9 States)*
      * *Used Mosiac (Data Management) tool for 2010 through 2015*
  + CornOnly
    - *The CDL files for 2010 through 2015 of Corn only (see above for corn types)*
      * *Used Extract By Attributes tool*

CDL/Years2010-15

* Region
  + AllCrops
    - *The CDL files for 2010-2015 merged into 1 raster*
      * *Used Mosaic (Data Management) tool*
  + CornOnly
    - *The CDL files for 2010-2015 merged into 1 raster for Corn only*
      * *Cdl\_corn1 (reclassified types into a value of 1) and cdl\_corntype*
      * *Used Mosiac (Data Management) tool on the CornOnly files*

Soils/

* States
  + 30m soils rasters (including a field called STMUKEY)

Boundaries/

* *Midwest*

Soils\_in\_CDL/

* States
  + CornOnly
    - Rasters of the soils (STMUKEY) where the crop has been grown in the past 6 years by state
    - <state>\_split
      * The same data but split into smaller rasters for processing
      * Also contains point shapefiles of the data and csv files of the attribute tables

Weather/

* Shapefiles for NLDAS weather grid polygons for the Midwest and for each state (with a buffer)
* Csv file with the centroids of each NLDAS weather grid
* Weather\_XML\_Backup/
  + Contains zipped files of the xml weather files for 1980-August 2016

Wx\_for\_Soils/

* <state>\_wx\_soil\_unique.csv
  + *Unique combinations of weather coordinates and soil type. This file is used to create the file used in SALUS (*<state>\_wx\_soil\_unique\_SALUS.csv)
* <state>\_wx\_soil\_unique\_SALUS.csv
  + *Weather coordinates and their associated MUKEYs (each weather coordinate is a new row)*

SALUSresults/CornOnly/

* results\_csv
  + <state>\_<chunk>\_<scenario>\_finalresults
    - Min, max, and average GWAD and CWAD, and max NLCC over the period 1980-2015
  + <state>\_<chunk>\_<scenario>\_finalresults\_<var>yearly
    - GWAD, CWAD, and NLCC results for each year (1980 to 2015)
* raster\_State\_GWAD
  + statewide raster for average GWAD and yearly GWAD
* raster\_State\_CWAD
  + statewide raster for average CWAD
* raster\_State\_NLCC
  + statewide raster for average maximum NLCC
* raster\_Midwest\_GWAD
  + Midwest raster for average GWAD and yearly GWAD
* raster\_Midwest\_CWAD
  + Midwest raster for average CWAD
* raster\_Midwest\_NLCC
  + Midwest raster for average maximum NLCC