THESIS Agriculture Yield Tool

1) Role within THESIS

The Agriculture Yield Tool combines the results of a series of idealized crop model simulations with a scenario time series of crop distributions to generate regional and global analyses of crop production, area, yield, fertilizer application, and irrigation, along with spatial maps of these same variables. Currently the tool is set up to work on the output of crop model simulations from CLM4.5 Crop and ISAM for historical climate (1900 – 2005) and the two future Representative Concentration Pathway climates of RCP 4.5 and RCP 8.5 (2006 – 2100). The tool is generically flexible however, and can be configured to work with other crop models and climate period outputs if it is arranged in the format of the Agriculture Yield Tool.

2) General description

The Agriculture Yield Tool assesses the individual and combined impacts on agriculture from changes in climate, atmospheric CO2, management and crop distributions for each year of a time series from a given scenario. The idealized crop model simulations are simulated over time with atmospheric conditions that have either fixed or changing climate and/or atmospheric CO2. The simulations also investigate the impacts of changing management through changing the application of fertilizer and irrigation. The idealized crop simulations report annual values of each of these model outputs for all possible crops in all land grid cells globally at 0.5 degrees resolution. The combination of climate, CO2 and management produces a database of crop model simulations:

- Model: clm, isam
- Period: historical, RCP 4.5, RCP 8.5
- Climate: constant, transient
- CO2: constant, transient
- Irrigation: rainfed, all irrigated
- Fertilizer: no fertilizer, US level fertilizer

The scenario time series crop distributions prescribe the fraction of each 0.5 degree grid that contains rainfed and irrigated areas of the six crops for each year in the time series:

- Cotton
- Maize

- Rice
- Soy
- Sugar Cane
- Wheat

The Agriculture Yield Tool combines the idealized crop model simulation database with the scenario time series of crop distributions and a regional time series of annual fertilizer application by crop, to produce all possible combinations of climate, CO2 and management for individual crops and for collections of crops. The output of these analyses are then available for further investigation and use with other components of the THESIS tool set. Details on CLM Crop modeling can be found at htpps://chsp.ucar.edu/research/crop-modeling

Relevant publications

Levis, S., Badger, A., Drewniak, B., Nevison, C., Ren, X., 2016. CLMcrop yields and water requirements: avoided impacts by choosing RCP 4.5 over 8.5. Climatic Change 1–15. DOI:10.1007/s10584-016-1654-9.

Meiyappan, P., Dalton, M., O'Neill, B.C., Jain, A.K., 2014. Spatial modeling of agricultural land use change at global scale. Ecological Modelling, 291, 152-174, DOI: 10.1016/j.ecolmodel.2014.07.027.

Ren, X., Weitzel, M., O'Neill, B.C., Lawrence, P., Meiyappan, P., Levis, S., Balistreri, E.J., Dalton, M., 2016. Avoided economic impacts of climate change on agriculture: Integrating a land surface model (CLM) with a global economic model (iPETS). Climatic Change, 1-15. DOI:10.1007/s10584-016-1791-1.

Citation for Model Code:

Ren, X., Weitzel, M., O'Neill, B.C., Lawrence, P., Meiyappan, P., Levis, S., Balistreri, E.J., Dalton, M., 2016. Avoided economic impacts of climate change on agriculture: Integrating a land surface model (CLM) with a global economic model (iPETS). Climatic Change, 1-15. DOI:10.1007/s10584-016-1791-1.

3) Specific features

3.1) Code description

This tool uses two driver bash shell scripts to create crop yield data for a given crop time series and then produces summary statistics for that crop time series. This tool assumes climate model output data available for input.

This tool was created by Peter Lawrence (NCAR).

3.2) Inputs

o This tool assumes climate model output data available for input, is in a particular netcdf format, and is organized in a particular way underneath a root directory specified by a dataroot variable. By default dataroot="/project/iams/thesis/data/agriculture_yield/clmcrop-isam/" This is where the data resides at NCAR.
$dataroot/clm/historical -- CLM model output
$dataroot/clm/rcp45
$dataroot/clm/rcp85
$dataroot/isam/historical -- ISAM model output
$dataroot/isam/rcp45
$dataroot/isam/rcp85
$dataroot/scenariodata -- associated data, eg. crop ID numbers, iPETS 0.5 degree mask

3.3) Running the tool

3.3.1) cropdatadriver.bash

o example of usage:
unix> ./cropdatadriver.bash SSP3_RCP45_160602 >& cropdatadriver.out

o Valid values for "croptimeseries" are defined here:
$datroot/scenariodata/cropareanamelist.txt
This is in the THESIS database in the agriculture_yield directory. In this file, the leftmost column is an ID/name, and the other columns are options associated with the ID.
o The output of this tool is a series of global 0.5 degree netcdf files which are placed into ../cropdata These files have croparea, production, fertilizer and irrigation values for each year specified in the "croptimeseries". The resulting files have names that reflect the combination of options used, eg:
model_croptimeseries_crop_climate_co2_irrigation_fertilizer_0.5x0.5.nc

o The "croptimeseries" defines both the crop area time series for each crop and the "Idealized Crop Data" simulation to be used with it.

o The crop area time series data is the output of a model's (CLM or ISAM) crop simulation (historical, RCP4.5 or RCP8.5) wherein all grid cells contain yields for all crops for all combinations of:
Model [clm|isam] x
Climate [const|trans] x
CO2 [const|trans] x
Irrigation [rf|irr|both] x
Fertilizer [nofert|fert|unfao]
When this data is combined with specific crops grown (eg. as would result from a specific

SSP), then specfic crop yields can be computed.

o this driver calls subscripts, the calling sequence is:
cropdatadriver.bash -> runcreateallcropdata.bash -> runcreatecropdata.bash -> createcropdata.ncl (ncl)

3.3.2) cropsummarydriver.bash

o example of usage:
unix> ./cropsummarydriver SSP3_RCP45_160602 >& cropsummarydriver.out

o Generates global and regional annual total text files in ../cropsummary for croparea, production, fertilizer and irrigation for each year in the "croptimeseries". This is uses the output data from (1) above, found in its ../cropdata output dir.

o The output of the cropsummarydriver is a series of text files which are placed into ../cropsummary with the name indicating the options used:
* model_croptimeseries_crop_climate_co2_irrigation_fertilizer_croparea.txt
* model_croptimeseries_crop_climate_co2_irrigation_fertilizer_cropproduction.txt
* model_croptimeseries_crop_climate_co2_irrigation_fertilizer_cropirrigation.txt
* model_croptimeseries_crop_climate_co2_irrigation_fertilizer_cropfertilizer.txt

o this driver calls subscripts, the calling sequence is:
cropsummarydriver (bash) -> runcreatecropsummary (bash) -> createcropsummary.ncl (ncl)