GAMCAF: A Geospatial Agricultural Management and Crop Assessment Framework for Regional Food Security

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Overview

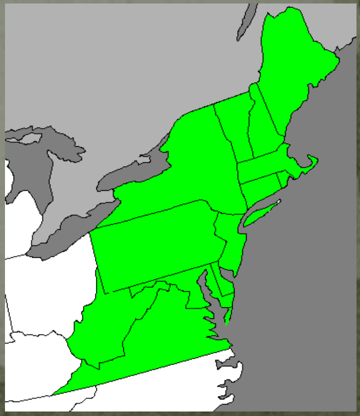
- 1) Why?
  - Project motivation
- 2) What?
  - Spatial data
  - Models
  - Linkages
- 3) How?
  - Case studies
- 4) When?
  - Future efforts

Why?

Motivation

Why a geospatial framework?

- U.S. Eastern Seaboard Region (ESR)
  - 65 to 80% fresh fruits / vegetables 'imported'
    - ↑fuel costs & food miles ; risk; ↑population; climate -> food security
  - Can ↑locally produced food reduce risks?
- Framework to assess potential production
  - What can be produced with natural resource base?
  - Sensitivity of production to:
    - Reconfiguration of land-use, resource management
    - Climate change
  - Production of 'yield-maps'
- What are biophysical constraints?
    - Temporal and Spatial aspects



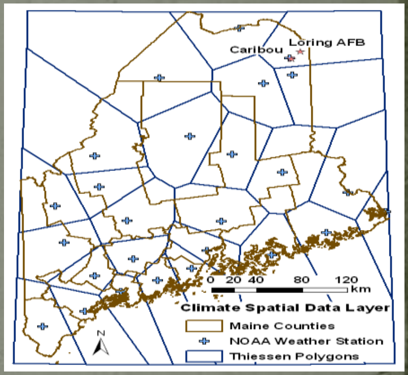
What?

Components

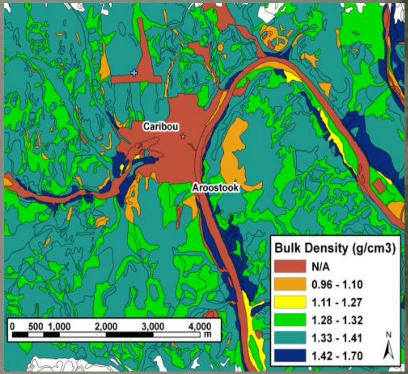
What is GAMCAF – Data

Geospatial Agricultural Management & Crop Assessment Framework

- Weather (NOAA-NCDC)
  - 378 NOAA Weather Stations
    - Historical Daily and monthly data (Precip, Tmax/min, Rad)



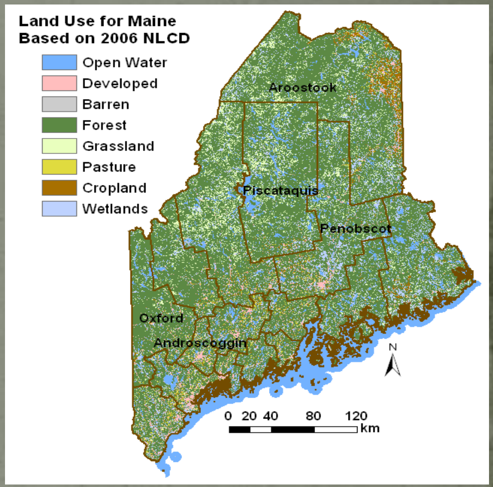
- Soil (NRCS, 2012)
  - SSURGO (1:24,000 Scale Polygons)
    - Dominant soil type selected for each 'map unit'
    - Physical and hydraulic properties for 4 horizons



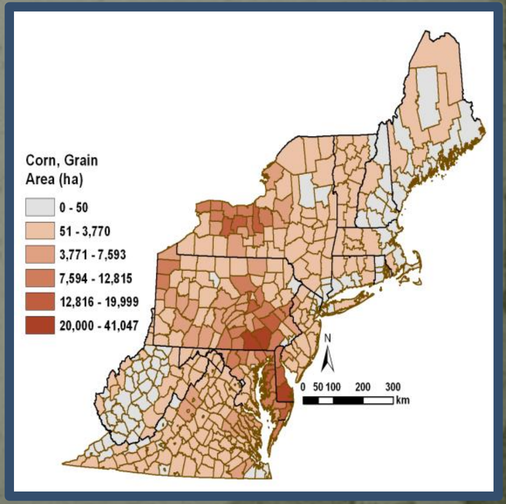
- Management (USGS, 2011; NASS, 2010)
  - National Elevation Dataset (NED) (30 m)
  - Planting and Harvesting Dates (State-level) (NASS)

What is GAMCAF – Data

- Land Use (USGS, 2011; NASS, 2011; FSA, 2011)
  - National Land Cover Dataset (NLCD) (30 m)
    - remote sensed land cover categories
  - Cropland Data Layer (CDL) (30 m)
    - multiple sources to ID crop cover
  - Common Land Unit (CLU) (Field-scale Polygons)
    - aerial photography delineates field boundaries

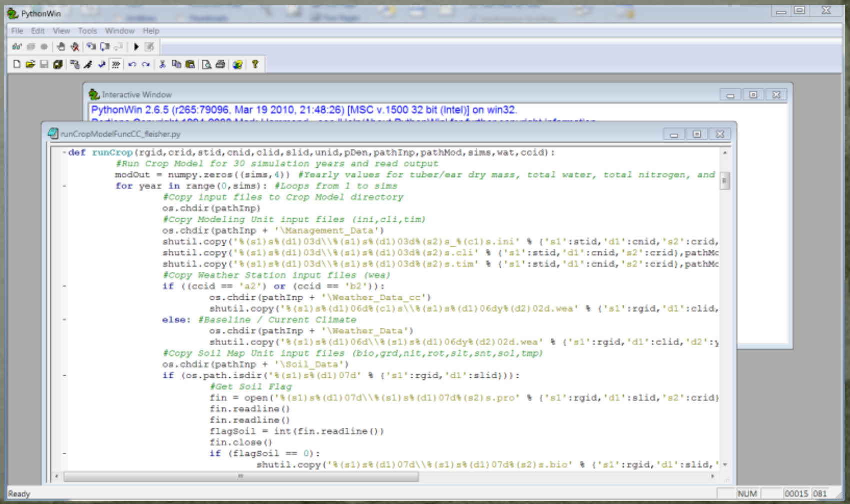


- 'Ground-truthing' (NASS, 2010)
  - Observed Area and Yield
    - State and County for selected years



What is GAMCAF – Models & Tools

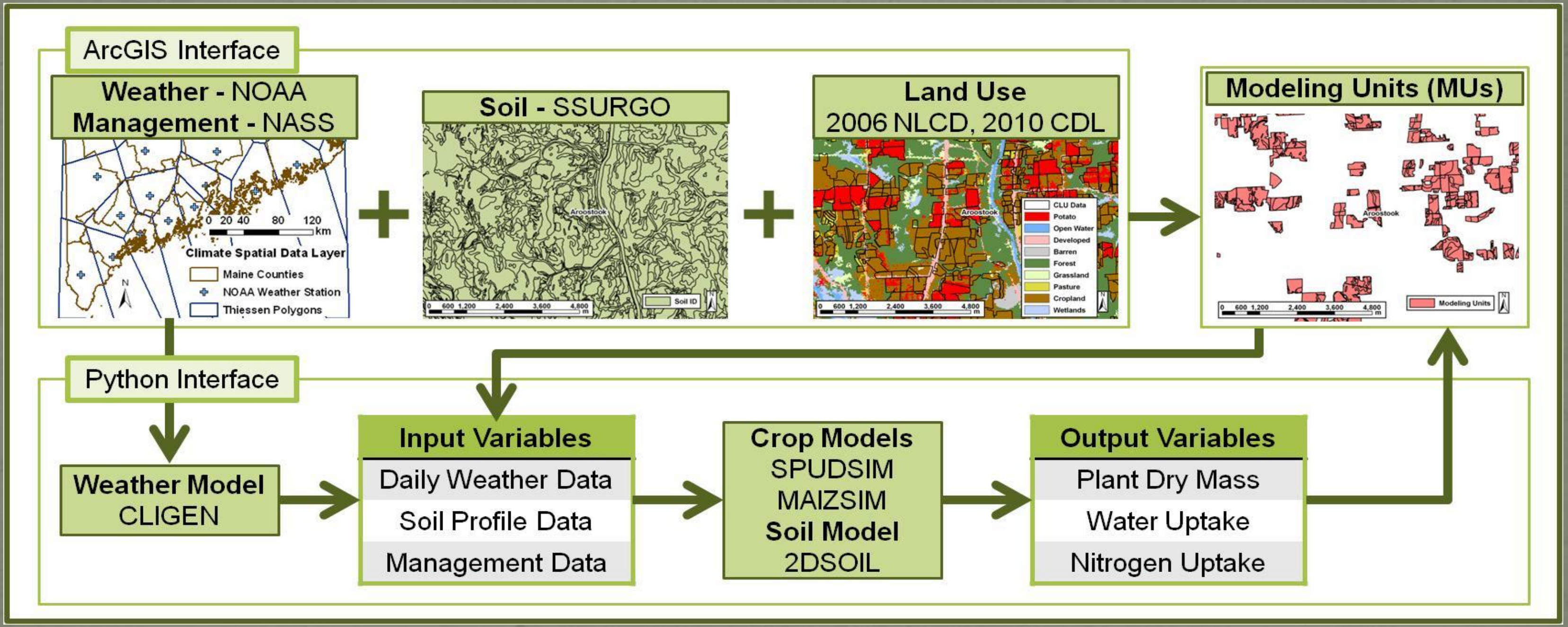
- Weather
  - CLIGEN (Nicks et al. 1995)
    - Simulate daily values based on history
- Soil
  - ROSETTA (Schaap et al., 2001)
    - Obtain van Genuchten parameters from SSURGO
- Crop
  - SPUDSIM – potato
  - MAIZSIM – corn
  - *CERES* – *wheat*
- Scripting, Data visualization
  - PYTHON
  - ArcGIS



What is GAMCAF – Interface

1) Input data layers (weather, soil, management, land use) are georeferenced and organized in ArcGIS for the region of interest.

2) Spatially homogeneous modeling units (MUs) are created.



3) For each unique input combination, 30 independent growing seasons are simulated with SPUDSIM and MAIZSIM.

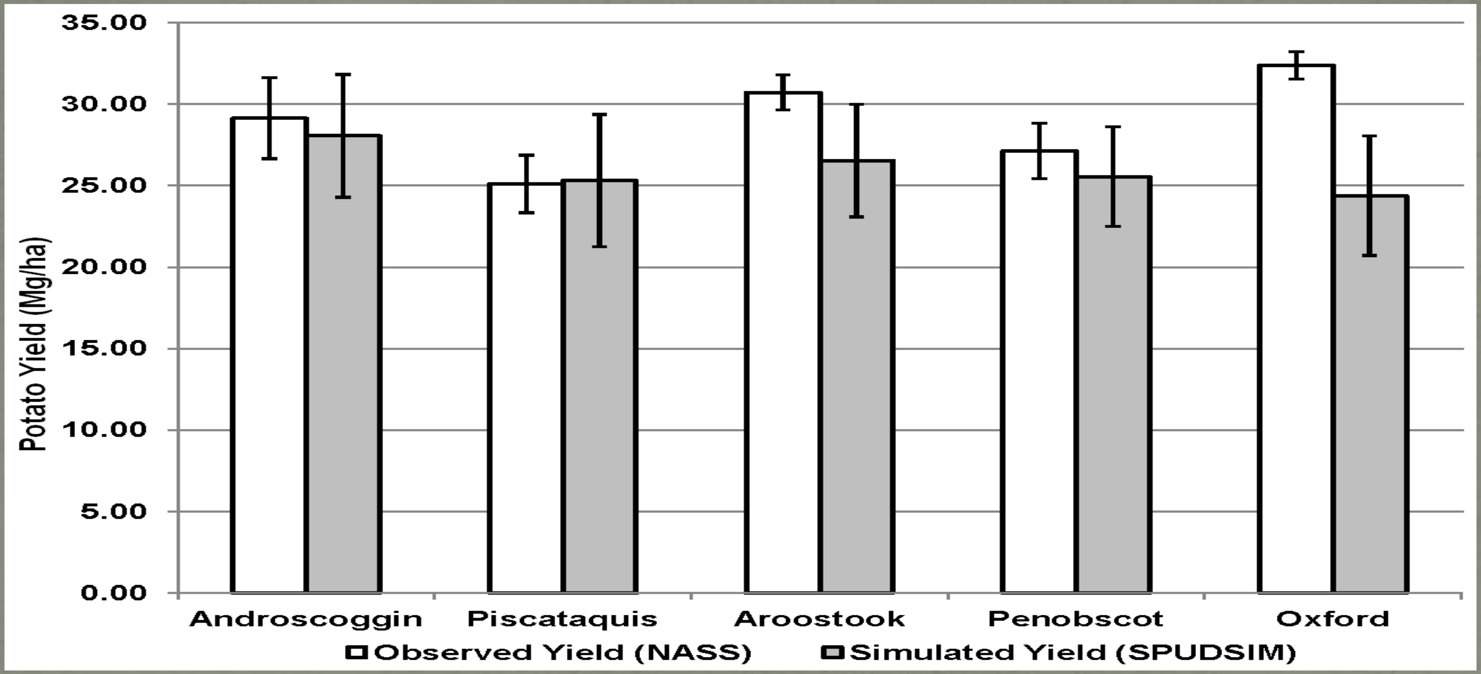
4) Output is spatially linked and aggregated to the county level.

How?

Case Studies

Case study 1: Maine & Potato

- What is upper limit to potato production (land-use)?
  - Ground Truthing – simulated vs NASS:



  - Most within observed deviations
    - Oxford county discrepancy likely due to management

Case study 1: Maine & Potato

- Simulated rain-fed production – all cropland

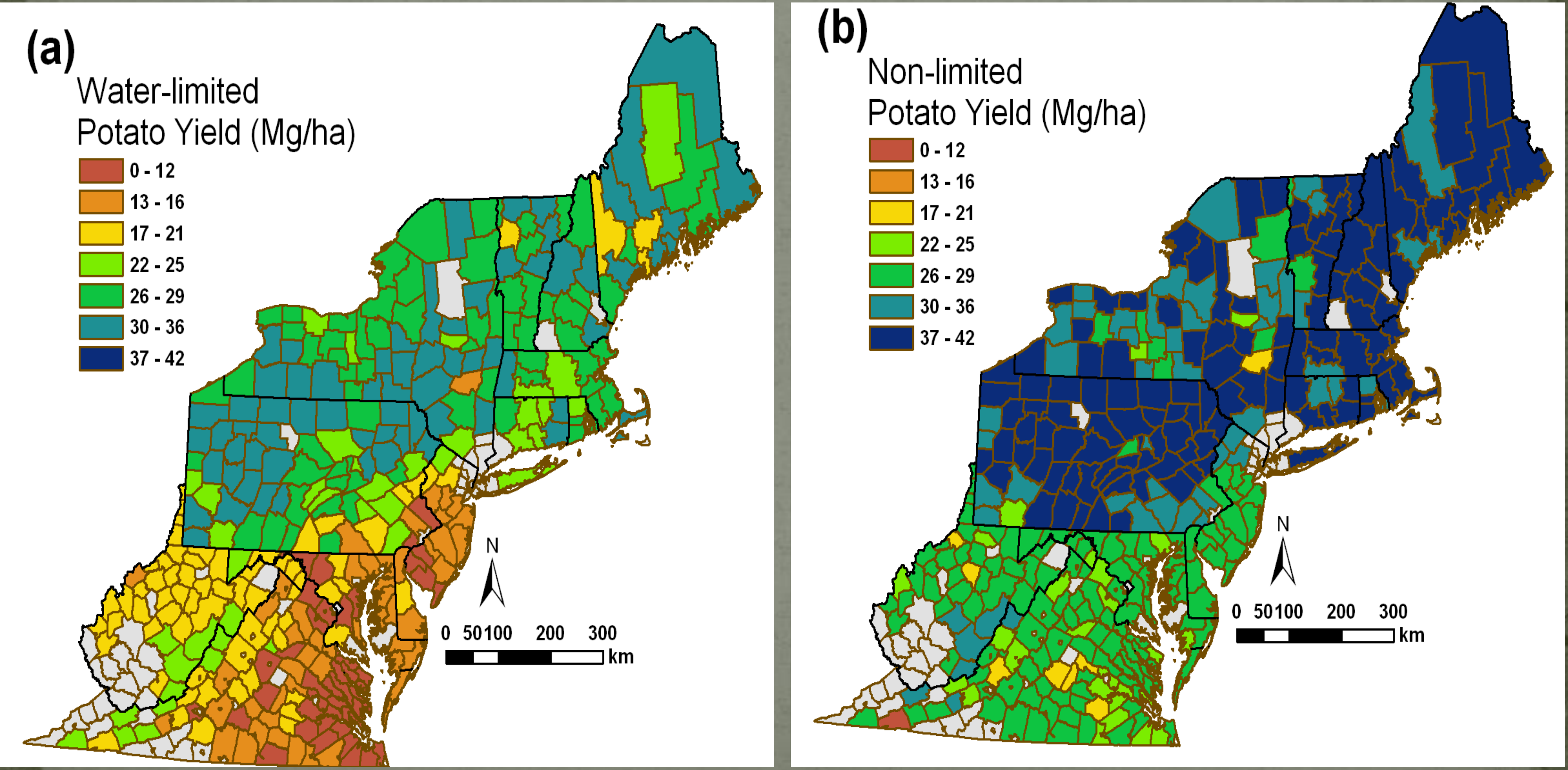
County	Potential Cropland (ha)	Average Yield (Mg/ha)	CV (%) (Overall)	CV (%) (Spatial)	CV (%) (Temporal)
Aroostook	75,763	26.23	13.5	6.1	7.2
Washington	9,897	24.18	14.0	5.7	10.8
Penobscot	9,733	25.36	12.4	5.3	8.5
Somerset	6,646	27.00	15.3	10.5	8.5
Kennebec	3,147	23.32	19.5	14.5	7.7
Oxford	2,684	23.99	16.7	13.5	7.9
Waldo	2,478	29.51	8.7	6.7	3.5
Piscataquis	2,179	26.06	15.7	11.5	7.2
Hancock	2,168	26.51	16.9	13.6	5.2
Androscoggin	1,369	27.21	14.4	8.3	10.7
Knox	1,363	31.71	9.0	5.3	6.5
York	1,313	25.31	18.5	13.0	9.6
Cumberland	1,022	25.57	15.1	10.9	6.8
Franklin	954	27.01	14.2	9.8	7.8
Lincoln	855	29.48	14.7	11.1	7.7
Sagadahoc	159	23.00	14.1	6.4	8.0

- Upper limit: 4x increase over current baseline

Adapted from: Resop, J.P., D.H. Fleisher, Q. Wang, D.J. Timlin, V.R. Reddy. 2012. Combining explanatory crop models with geospatial data for regional analyses of crop yield using field-scale modeling units. Comps & Electronics in Agr., 89: 51-61

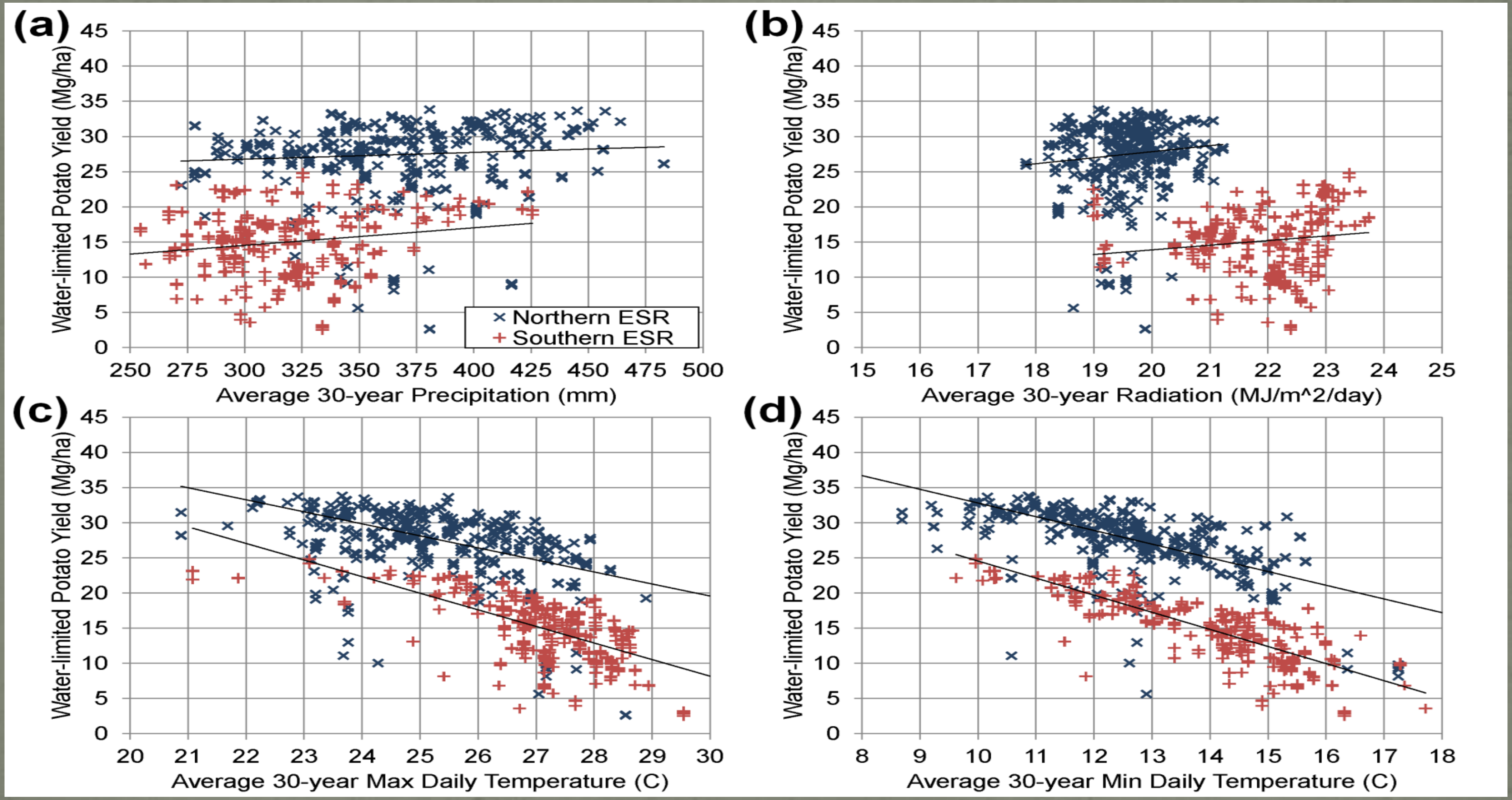
Case study 2 – ESR & Potato

(Simulated Over All Cropland)



Case study 2 – ESR & Potato

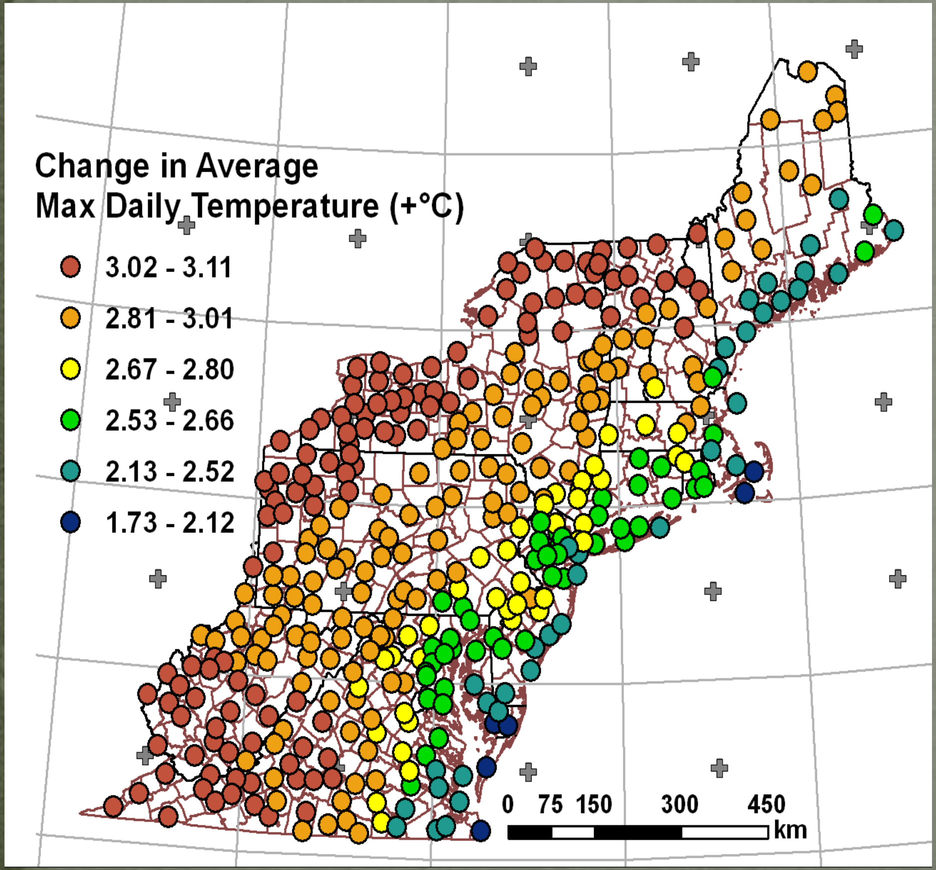
- Biophysical constraints (Northern / Southern ESR)

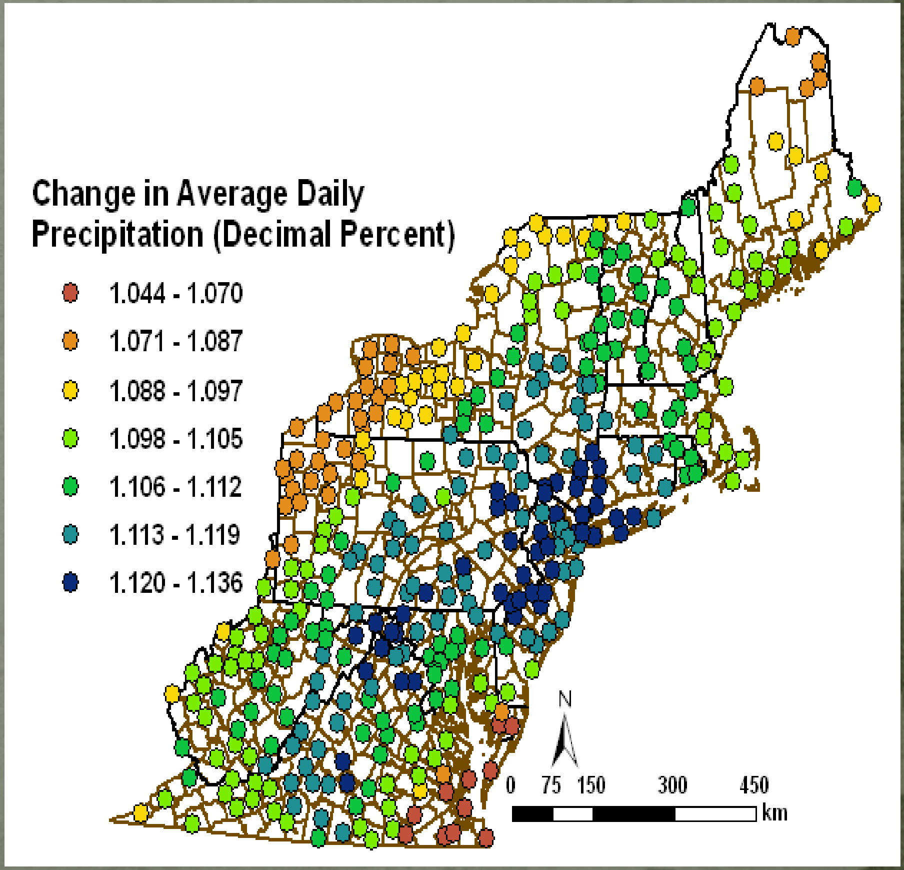


Adapted from: Resop, J.P., D.H. Fleisher, D.J. Timlin, V.R. Reddy. 2013 (in press). Biophysical constraints to potential production capacity of potato across the U.S. Eastern Seaboard Region. Agron. J., in press.

Case study 3 – ESR & Climate Change

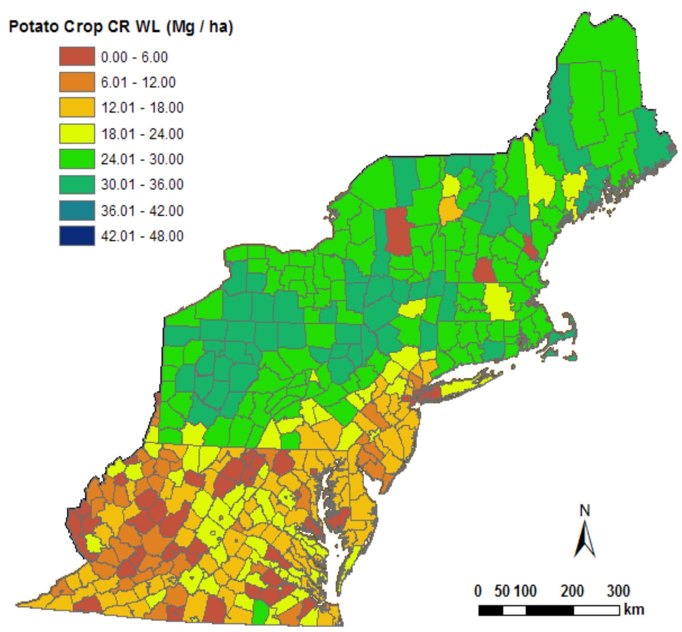
- GCM data downscaled using IDW method to the NOAA CLIGEN parameters
- Future predictions are averaged over the time frame 2050 to 2080
- Climate Scenarios = A2 (Focus on Economic Development, High CO_2 ~600 ppmv)

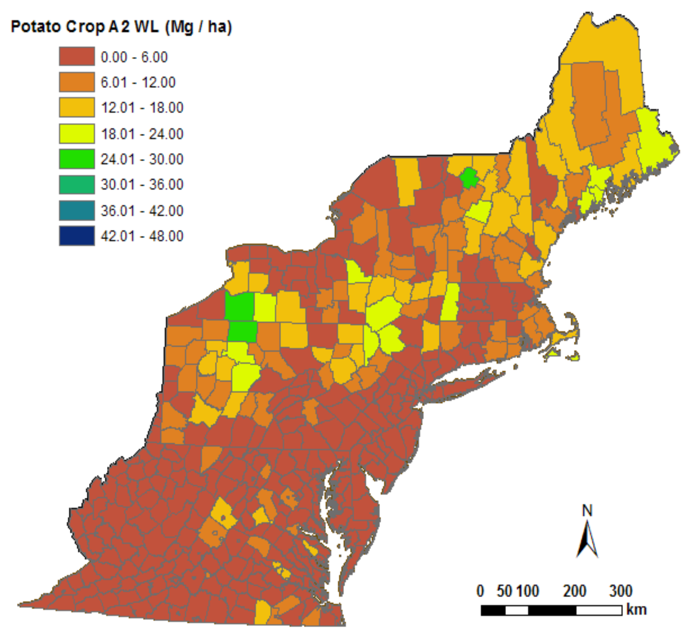




Case study 3: ESR & Climate Change

- Potato crop-land : Current vs Mid-Century A2 (worst-case)

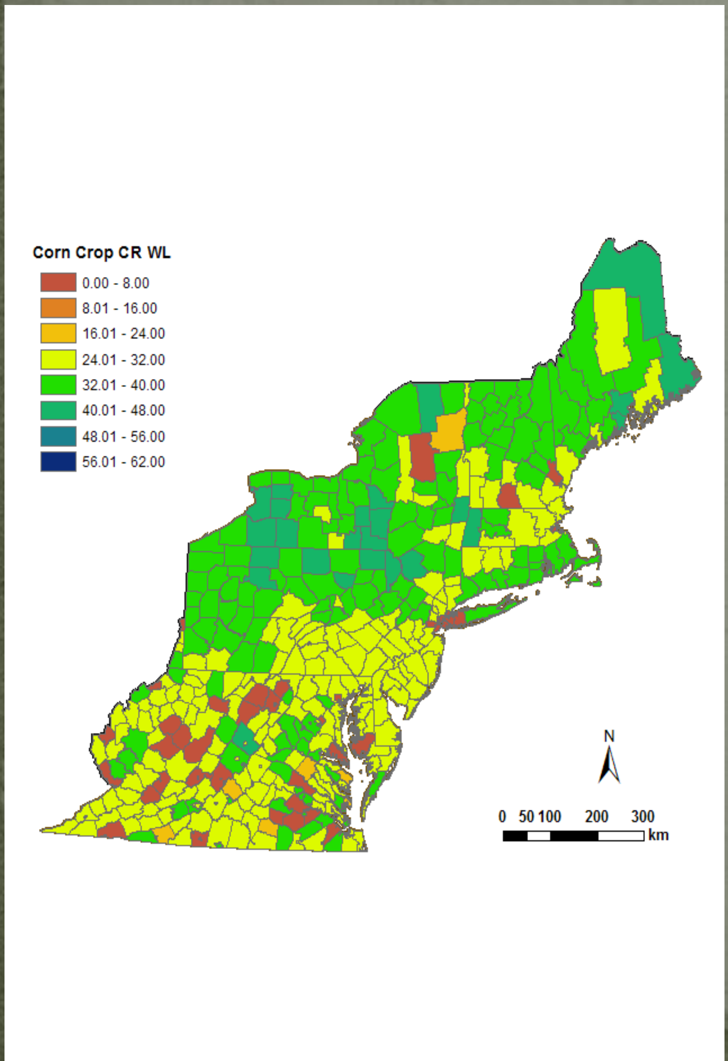


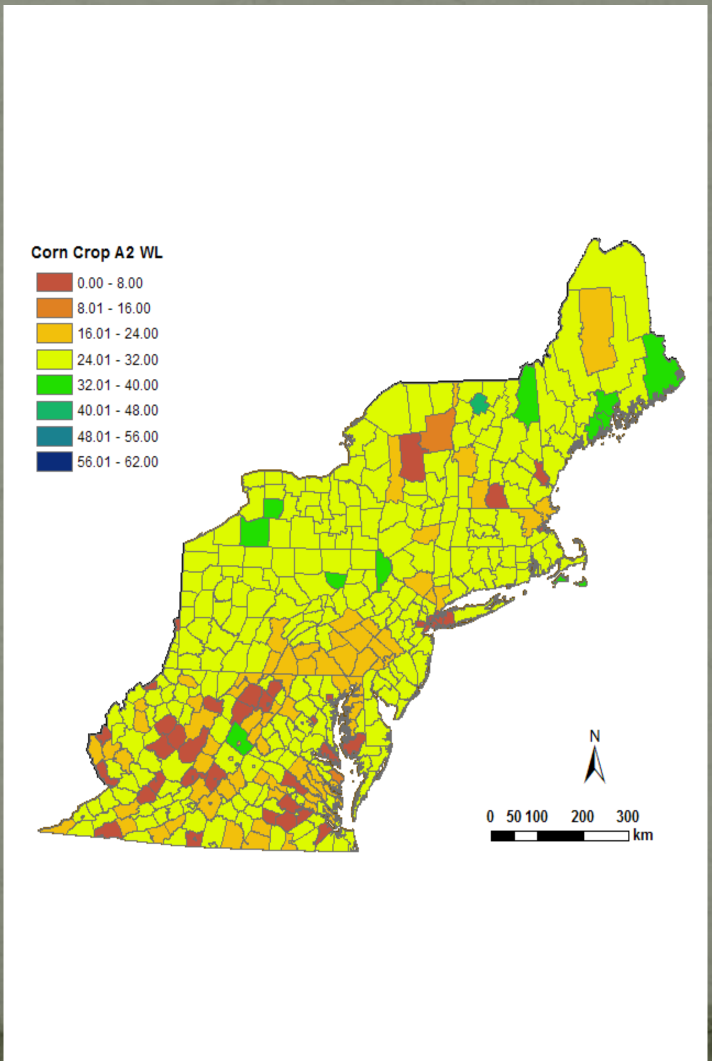


Percent Yield Declines	
Potato	
State	WL->A2
ME	-50
VT	-55
RI	-80
NH	-59
MA	-66
CT	-76
NY	-72
PA	-87
NJ	-71
MD	-87
DE	-90
WV	-79
VA	-76
MEAN	-70%

Case study 3: ESR & Climate Change

- Corn crop-land: Current vs Mid-Century A2





Percent Yield Declines	
Corn	
State	WL->A2
ME	-23
VT	-24
RI	-20
NH	-19
MA	-20
CT	-19
NY	-21
PA	-20
NJ	-18
MD	-17
DE	-14
WV	-22
VA	-17
MEAN	-17

Case study 3: ESR & Climate Change

- Adaptation Responses
  - Yield loss under fully-irrigated scenarios not as great:
    - (is this practical?)-
      - Potato – hypothetical yield loss at -17% (from 70%)
      - Corn – hypothetical yield loss at -4% (from 17%)

  - Planting / harvest dates:
    - Potato
      - hypothetical yield loss at -24 to -35% (from 70%)
    - Corn
      - hypothetical yield loss at -11% (from 17%)
    - Southern states show less adaptation potential (and more negative) effect of extending harvest dates than northern states

When?

Current & Future Research

Current / Future Work

- Additional commodities
  - + wheat + …;
  - ARS postdoc position available!

- Yield index
  - aggregate reference for ‘yield map’
  - representation of multiple commodities

- Marginal land assessment ‘productivity index’
  - input to supply chain / distribution

Questions?

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The CSGCL Geospatial Analysis Cluster Computing Center

Maryland – Post-Doctoral Researcher

The USDA-ARS Crop Systems and Global Change Laboratory in Beltsville, MD is seeking a postdoctoral associate for a 2-year appointment. **QUALIFICATIONS:** Recent Ph.D. in one of the following fields: Agricultural Engineering, Agronomy, Plant Physiology, Soil Science, or related discipline. Knowledge of crop responses to biophysical constraints, simulation models for plant growth, and GIS is highly desirable. **HOW TO APPLY:** Submit resume or curriculum vitae to Dr. David H. Fleisher, USDA-ARS, (david.fleisher@ars.usda.gov).

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