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
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**

<table>
<thead>
<tr>
<th>County</th>
<th>Potential Cropland (ha)</th>
<th>Average Yield (Mg/ha)</th>
<th>CV (%) (Overall)</th>
<th>CV (%) (Spatial)</th>
<th>CV (%) (Temporal)</th>
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</table>

- **Upper limit: 4x increase over current baseline**

Case study 2 – ESR & Potato
(Simulated Over All Cropland)

(a) Water-limited Potato Yield (Mg/ha)
- 0 - 12
- 13 - 16
- 17 - 21
- 22 - 25
- 26 - 29
- 30 - 36
- 37 - 42

(b) Non-limited Potato Yield (Mg/ha)
- 0 - 12
- 13 - 16
- 17 - 21
- 22 - 25
- 26 - 29
- 30 - 36
- 37 - 42
Case study 2 – ESR & Potato

- Biophysical constraints (Northern / Southern ESR)

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 CO₂ ~600 ppmv)
Case study 3: ESR & Climate Change

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

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<tr>
<td><strong>MEAN</strong></td>
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</table>
Case study 3: ESR & Climate Change

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

**Percent Yield Declines**

<table>
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<td>-17</td>
</tr>
<tr>
<td><strong>MEAN</strong></td>
<td><strong>-17</strong></td>
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</tbody>
</table>
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?

This research was supported by the USDA-ARS Headquarters Postdoctoral Research Associate Program and the USDA-NIFA AFRI Grant #2011-68004-30057: Enhancing Food Security of Underserved Populations in the Northeast through Sustainable Regional Food Systems.

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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