Design of Remote Sensing Based US National Crop Progress Monitoring System (NCPMS)

Zhengwei Yang[1,2], Liping Di[2], Genong Yu[2], Rick Mueller[1]
[1]Research and Development Division, USDA NASS
[2]Center for Spatial Information System Science
George Mason University
Zhengwei_yang@nass.usda.gov

Project Background

- NASS RDD & GMU Center for Spatial Information System Science's joint project supported by NASA Earth Science Decision Support Program.
- NASA awarded a competitive grant dedicated to this project in April 2009.
- Project period: 4 years (08/2009-08/2013)

Project Goals

- Enhance operation and improve the science, objectivity, robustness and defensibility of nationwide crop progress and condition monitoring at NASS
- Develop and prototype an operational National Crop Progress Monitoring System (NCPMS).
- Produce crop progress data products from NCPMS that will be complementary to existing NASS Crop Progress products.
- Enhance data accessibility, interoperability and dissemination.

Why does NASS need a Remote Sensing Based Crop Progress Monitoring System?

- NASS currently conducts weekly, volunteer-based crop progress surveys, and publishes crop progress and condition reports.
- The current crop progress monitoring is
  - point-based sampling
  - subjectively estimated
  - lacks spatial distribution information
  - Inconsistent observation results
- Remote sensing technology provides:
  - Objective, consistent, science based, geospatially covered, time series observations.

Major System User Requirements

- Minimum reporting area enforced to guarantee privacy.
- Interactive crop progress map generated.
- Pixel-level or field level granularity
- On-the-fly presentation within user defined region.
- Geospatial query capability.
- Crop specific phenological information.
- Equal accession and dissemination via spatially enabled Web-based systems to facilitate equal information access.

Methodology of Remote Sensing-based Crop Progress Estimation

- The project will develop a remote sensing-based crop progress indicator for major crops (e.g., Corn, Soybean, Wheat)
  - Based on time-series remote sensing parameters of vegetation activities
    - Vegetation index, LAI, fPAR
  - Using other remotely sensed vegetation growth conditions
    - LST, precipitation, soil moisture
  - Incorporate the weather data
- The derived indicator will be correlated with field-observed crop progress data to obtain the functional relationship between the progress and the remote sensing based indicator.

Data Sources

- NASA MODIS products
  - NDVI, VIs, Leaf Area Index (LAI), Fraction of Photosynthetically Active Radiation (fPAR), and Land Surface Temperature (LST), etc.
- Other NASA remote sensing data
  - Preciptation - Tropical Rainfall Measuring Mission (TRMM) & others
  - Soil moisture - 25-km global soil moisture derived from Aqua AMSR-E
- USDA NASS CDL & historical crop progress data
- USDA FSA CLU & 578 Administrative data
- NOAA weather data
- Project specified field observation data

Design Principles of Operational NCPMS

- The system should be able to assimilate and prepare Earth Observing data for use in agricultural crop growth monitoring and accuracy improving.
- The system should be capable of efficiently (timely) applying Earth Observing research results and data in crop growth development estimation.
- Advanced data mining algorithms and crop models should be implemented and can be plugged-in to readily take advantage of resources available in the system.
- Systematic approaches should be applied to
  - integrate data, services (Web computer software programs)
  - disseminate results through the Web
  - operate the national crop progress monitoring system in a standard-compliant virtual Web environment.

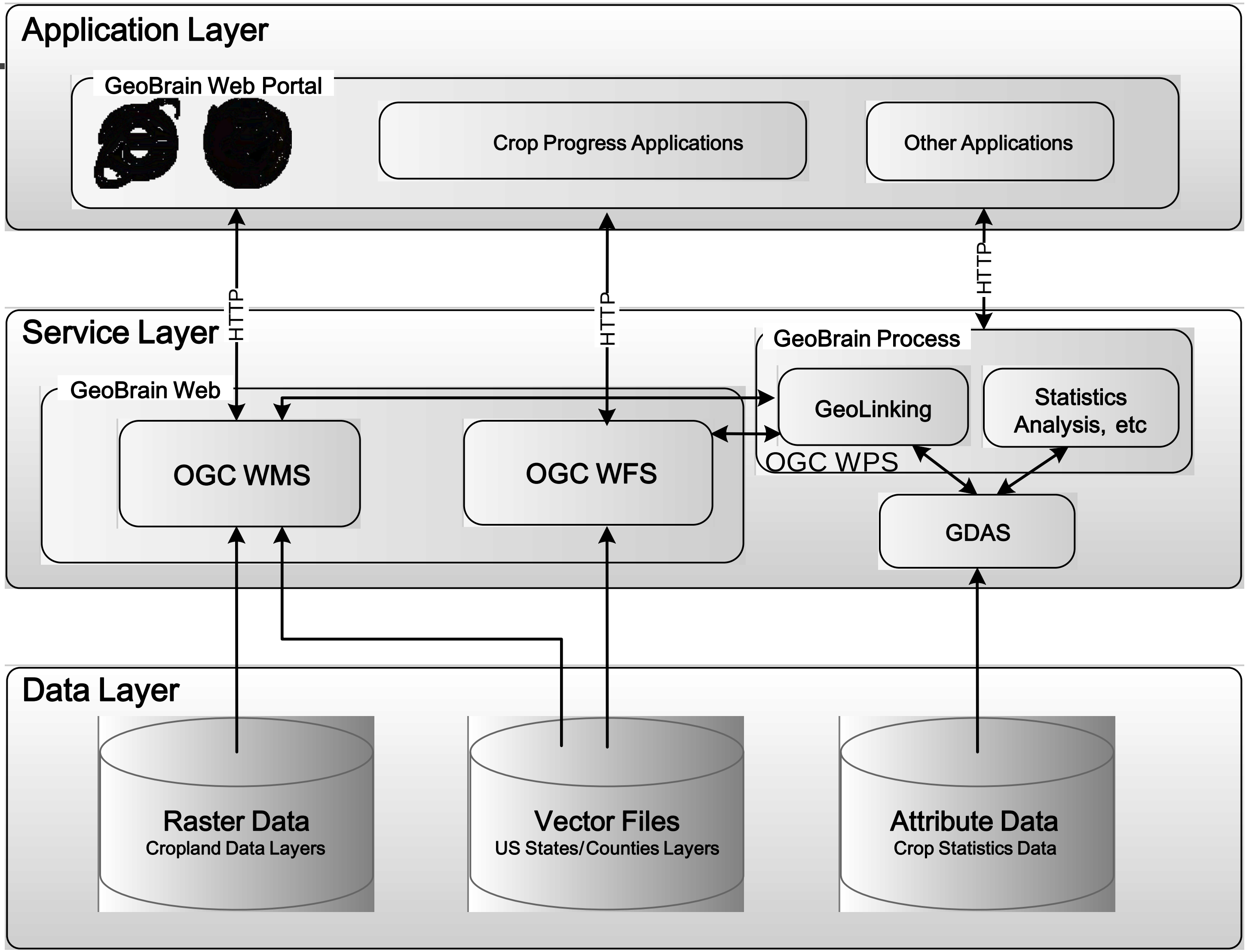
Considerations of Architecture Design and Technology

- Web Based Service Oriented Architecture
- OGC standard compliant web services:
  - Web Feature Service (WFS), Web Map Service (WMS), Web Processing Service (WPS), Sensor Observation Service (SOS), etc.
- Service Integration
  - Support of workflows: Business Process Execution Language (BPEL), BPEL execution engine
  - Re-use all algorithms published in WPS
- Re-use functions/algorithms developed

Service-Oriented Architecture (SOA)

- Open Architecture
- Integrates data and processes via interoperable services
- Comprehensive Standard API
- Accessible through HTTP
- Scalable, Robust, and Reusable

Service-Oriented Architecture (SOA)



Data Layer

- Vector data files (in PostgreSQL DB)
  - US state, county, ASD or other boundaries
  - Statistical maps
- Attribute Data (in PostgreSQL DB)
  - Various NASS survey statistical data
- Other Raster data (RAID disks)
  - Satellite images in GeoTIFF

Service Layer - OGC Compliant

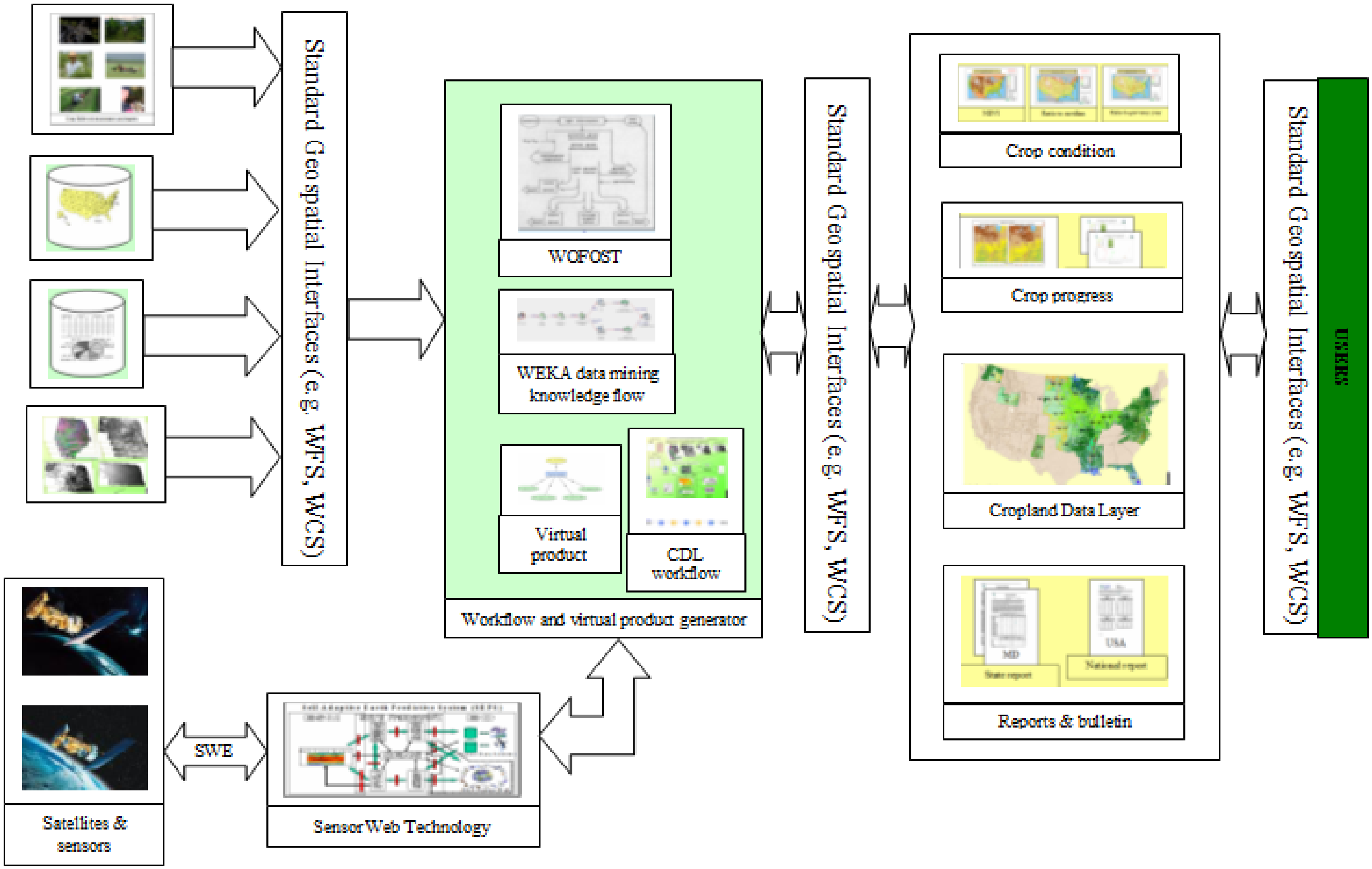
- Implement web services to fulfill various tasks such as data retrieving, visualization, query and dissemination
- Web Feature Service (WFS) server
  - Serves vector files, attribute data
- Web Map Service (WMS) server
  - Handles the map data rendering and manipulation
- Web Processing Service (WPS)
  - Implements various application functionalities such as downloading, on-line analytics, data visualization, etc.
- GeoLinking Service (GLS)
  - Merges geo-linked data based on linking attributes
- Geolinked Data Access Service (GDAS)
  - Implements online access to the vast number of data collections

For each operation defined in these services, **HTTP GET/KVP** (Key-value pair) and **HTTP POST/XML** are supported

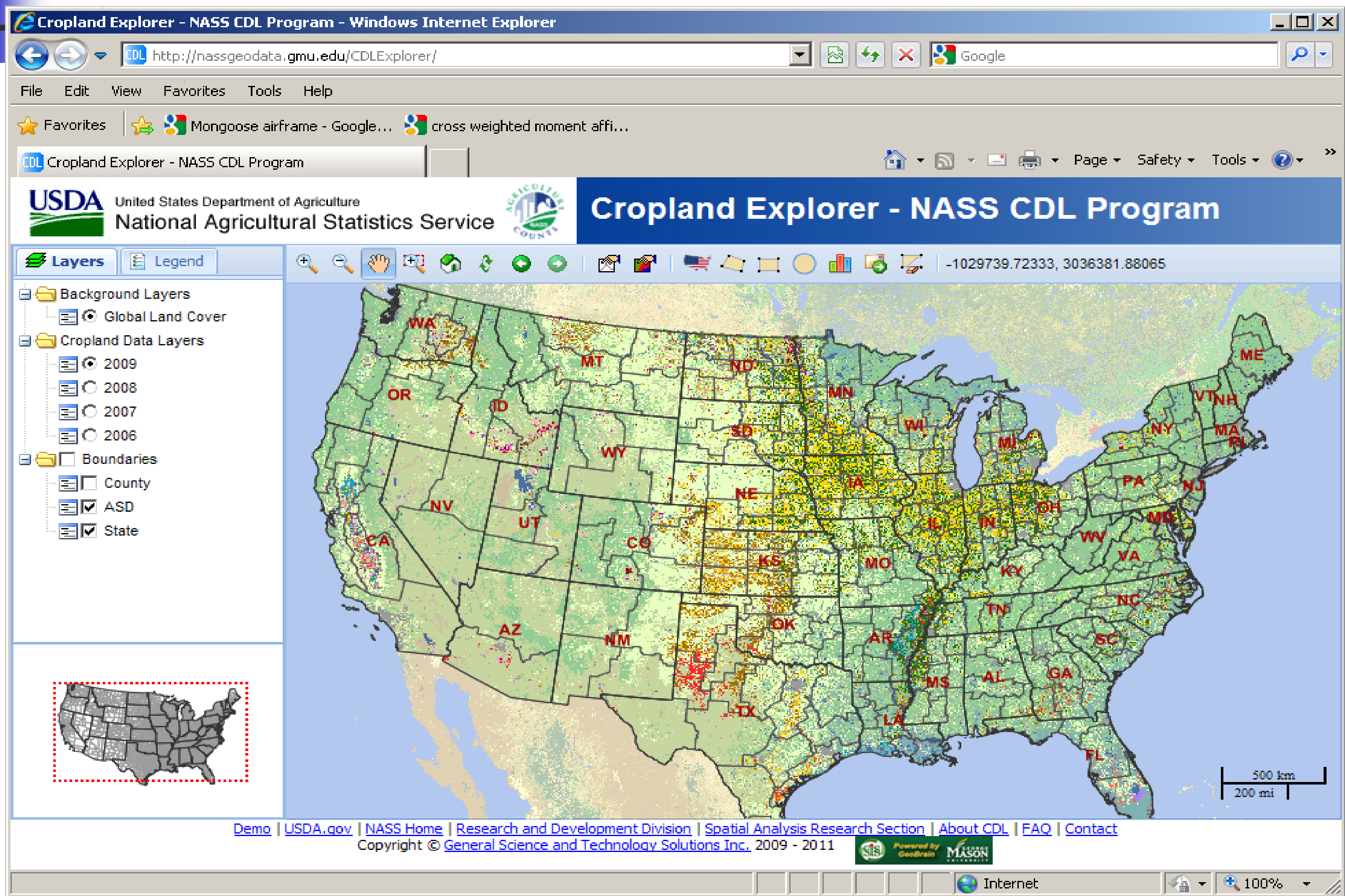
Application Layer

- Includes
  - Browsers – IE, Firefox, Google Earth, etc.
  - System performing crop progress monitoring
    - Data processing;
    - Crop progress estimation;
    - Map presentation of crop progress;
    - Geo navigation;
    - Attribute querying;
    - Zooming & panning;
    - Geospatial querying;
    - Visualization;
    - And more …

The NCPMS Architecture

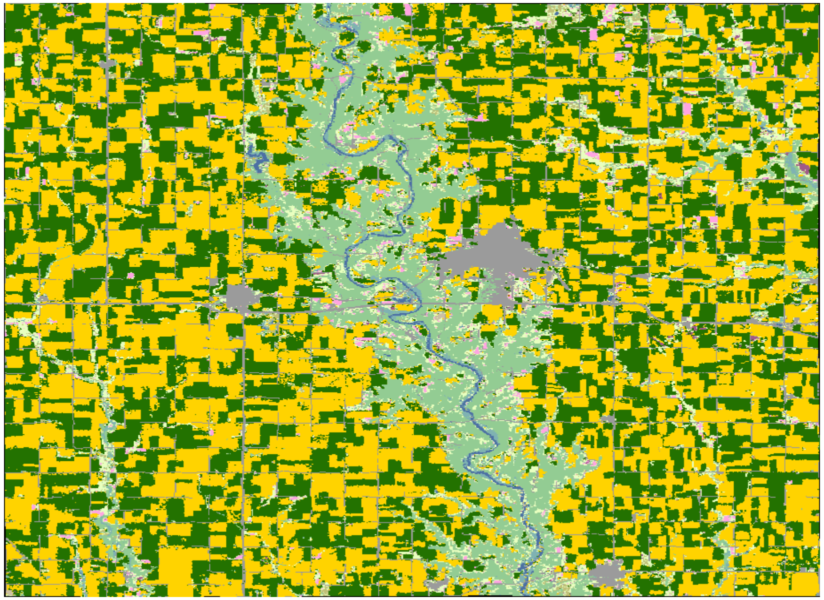


Data Dissemination & Visualization Example – Cropland Explorer



Web Service Demos

a) http://nassgeodata.gmu.edu/CDLExplorer/GetCDL?year=2009&fips=19015
b) http://nassgeodata.gmu.edu/CDLExplorer/GetCDLStatData?year=2009&fips=19015



a)

Value	Category	Acreage
1	Corn	156661.3
5	Soybeans	100869.2
12	Sweet Corn	1.5
24	Winter Wheat	13.2
28	Oats	389.8
36	Alfalfa	327.8
37	Other Hays	486.7
59	Seed/Sod Grass	2.3
61	Fallow/Idle Cropland	0.8
62	Grass/Pasture/Non-Ag	3313.6
63	Woodland	13.9
87	Wetlands	41.8
111	NLCD - Open Water	2064.4
121	NCLD - Developed/Open Space	29350.2
122	NCLD - Developed/Low Intensity	3873.8
123	NCLD - Developed/Medium Intensity	708.3
124	NLCD - Developed/High Intensity	206.1
131	NLCD - Barren	93.0
141	NLCD - Deciduous Forest	34563.8
142	NLCD - Evergreen Forest	7.0
143	NLCD - Mixed Forest	0.8
152	NLCD - Shrubland	19.4
171	NLCD - Grassland Herbaceous	10842.7
181	NLCD - Pasture/Hay	21097.2
190	NLCD - Woody Wetlands	1896.2
195	NLCD - Herbaceous Wetlands	285.9

b)

Questions & Comments?

NASS: Zhengwei_yang@nass.usda.gov

GMU: Ldi@gmu.edu