OGC Disasters Resilience Pilot User Guide

Rapid Assessment for Flood, Hurricane, and Agriculture Condition

by CSISS, George Mason University

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Chapter 1. Introduction

This User guide provides guidance for using the geospatial capabilities available at the Center for Spatial Information Science and Systems, George Mason University and resources through the Web by taking advantages open standards and data/service to respond to needs of resource planners at dealing with different disasters - flooding, hurricane, and droughts.

The user guide addresses the needs of acquiring quick and timely information on disasters and their impacts by resource planners for them to allocate resources efficiently in events of disasters.

Who are the audience of this Guide? The guide is primarily target at serving the needs of resource planners to quickly obtain disaster impact information, especially on agriculture and cropland. If you need impact information of flooding, hurricane, and/or drought quickly and cost-effectively, you should be benefited with means and methodologies by following the guide to walk through the Web of technologies and use cases.

What are covered in the Guide? The main points are as follows.

- Means and tools for rapid assessment of disaster impacts on agriculture and cropland: CropScape, VegScape, RF-CLASS, and GeoPlatform
- Use cases for applying such means and tools in assessing impacts due to floods, hurricanes, and droughts
- Integration geospatially with human dimensions to provide location-aware services to resource planners

This Guide also reveals the role of open geospatial standards in supporting processing automation and data integration.

NOTE

In addition, this Introduction file helps the reader to better understand the various sections of the Guide. The main contents are briefed here as follows.

Highlights of main chapters:

Chapter 2 provides a general architecture that connects data providers, catalogue providers, and data consumers.

Chapter 3 introduces the general use cases by user activity.

Chapter 4 discusses the special topics.

Chapter 5 discusses three scenarios - flood, hurricane, and agriculture and food security - and their related tools.

Chapter 6 summarizes what achieved and where technologies fall short.

1.1. Flood

Flooding is one of the most frequent natural disasters in the world. According to the Organization for Economic Cooperation and Development, on average, floods cause over $40 billion in damage worldwide. U.S. alone account 20% of the global loss.

Floods cause more than $40 billion in damage worldwide annually, according to the Organization for Economic Cooperation and Development cite:[OECD2016]. In the U.S., losses average close to $8 billion a year cite:[OECD2016]. Significant death tolls have increased in recent decades.

For example, Hurricane Harvey in 2017 was the largest hurricane in past decade. Flooding account one of the largest damages from the storm.

Objectives: The flood scenario tries to provide a cost-effective, objective, rapid assessment of impact from extreme weather disasters. Deliver the results to information consumers quickly through an automated, geospatial processing workflow in the Web that accomplish the process from data to information, including data preparation, processing, computation, and product dissemination.

Disaster cases: Texas Hurricane Harvey FEMA DR-4332

User: Resource Planner

Use scenario: Use Sentinel and MODIS/VIIRS to quickly extract the extent map of flooded area and calculate Disaster Vegetation Difference Index (DVDI) - an indicator of disaster impact. Resource planners uses the information to efficiently allocate the resources in respond to flooding events.

1.2. Hurricane

A hurricane is one of the major natural hazards around coastal areas. Because of the low-pressure oceanic condition, a hurricane event causes high precipitation during its landfall. The agriculture sector especially crops are damaged because of the heavy precipitation due to hurricane events. Recent examples are Hurricane Harvey,and Hurricane Irma-induced flooding in 2017, which accounted for a million-dollar crop loss in the south-eastern parts of the US cite:[davidpike2018,quealy2017cost]. Therefore, it is important to monitor the impact of the hurricane on crop fields. Soil saturation is one of the indicators to monitor the impact of hurricane landfall. Crop condition and growth primarily depend on the balance of primary resources: soil, water, heat, and nutrients. Any extreme condition such as water shortage or extra water in the soil is detrimental to crop growth and yield. Plant water stress condition, agriculture drought, takes place when soil moisture goes below the wilting point because there is no water for plant uptake. Similarly, soil moisture at saturation level can significantly damage the crop, since crop roots are unable to adequately respire due to the insufficient oxygen in the soil pores cite:[rahman2017agriculture,universityofcaliforniadavis]. Therefore, monitoring of soil saturation can be helpful for crop damage assessment during hurricane landfall. It is impossible to monitor soil saturation with high frequency for the vast agricultural area by field-based measurement. Thus, satellite remote sensing-based soil moisture measurement is useful to monitor soil saturation over vast areas. Soil Moisture Active Passive (SMAP), a NASA's satellite mission, launched on January 2015, consisting of L-band microwaves Radar and Radiometer systems. It aims to provide global maps of soil moisture and freeze/thaw state every 2–3 days with high accuracy cite:[o2010nasa]. One of the key science applications of SMAP is to develop improved flood prediction and drought monitoring capabilities cite:[entekhabi2009soil]. SMAP level 4 (L4) represents the model-driven value-added data products, which provides surface soil moisture, root zone soil moisture, and carbon net ecosystem exchange to support SMAP key applications cite:[o2010nasa]. Catchment model soil porosity data of the SMAP soil moisture land model constant dataset is available from the National Snow and Ice Data Center cite:[reichle2018soil]. Thus, soil moisture content greater than effective soil porosity can be mapped as saturated soil. Moreover, cropland coverage and crop types data are available from national landcover data and cropland data layer (CDL). Hurricane impacted cropland information can be generated by combining cropland information, saturated soil maps, and county level boundary information. This information can quickly be disseminated through web mapping and cyberinfrastructure for the quick assessment of hurricane impact on croplands.

Disaster cases: Texas Hurricane Harvey FEMA DR-4332 and Louisiana Severe Storms and Flooding (DR-4277)

User: Resource Planner

Use scenario: Use SMAP data to quickly produce soil-moisture-statured area maps to give a quick lead where the landfall of hurricane events. A quick guide and information retrieval would provide resource planner with information of counties and people affected by hurricanes.

1.3. Agriculture and Food Security

Weather extremes have significant impact on agricultural productivity. Severe storms could damage crops immediately. In rain-fed area, severe drought could also cause immediate damage to crops in a large area. In irrigated area, an extended, long drought period could exhaust ground water resources and lead to unrepairable crop damage and yield reduction. Crops grow differently under different extreme weathers. The impacts are different with different crops and different events, as shown in Figure 1. Rapid and accurate information on how many acres cropland are affected and how serious the impact on yield after each of such severe weather events would greatly help resource planners in allocating resources to provide adequate, much-needed support to farmers.

Figure 1. Weather Conditions and Crops - Corn and Soybean in Nebraska, USA (Photography by the GMU team in Nebraska 2018 and 2019)

Remote sensing technologies integrated with geospatial information of human dimensions have been proven to be among the most efficient and cost-effective means to deliver the information products of disaster impacts on crops and assess their impacts on agricultural productivity. Studies showed that vegetation index values and their fluctuation over time series can be used to indicate crop yield and yield change respectively. The indices are effective means for quick assessment of disaster impacts on crop and its yield. The calculation of vegetation indices can be easily automated which make the process of estimating the impact to be readily processed and assessed with machine-to-machine processes under predefined workflows. The impact can be assessed and reported shortly after severe weather disasters happened by leveraging the standard interfaces and the automated chained processes of Web processing services.

In this pilot, a system, VegScape, is demonstrated in producing the crop condition maps automatically. Two types of severe weather disasters, severe storm and drought, were showcased with applications of such technologies in providing much-needed information to resource planners with impact area and assessment.

Disaster cases: Louisiana Severe Storms and Flooding (DR-4277) and Severe Drought in Kansas state during the North America Drought events

User: Resource Planner

Use scenario: Use MODIS/VIIRS to quickly produce crop condition maps. Resource planners use the crop condition data to quickly assess the impact of severe weather conditions on acgricultural productivity and allocate resources efficiently in responding to food security under pressure of disasters.

Chapter 2. Simple Architecture

This section will provide an architectural overview. The overall architecture and softwares stack are shown in Figure 2.

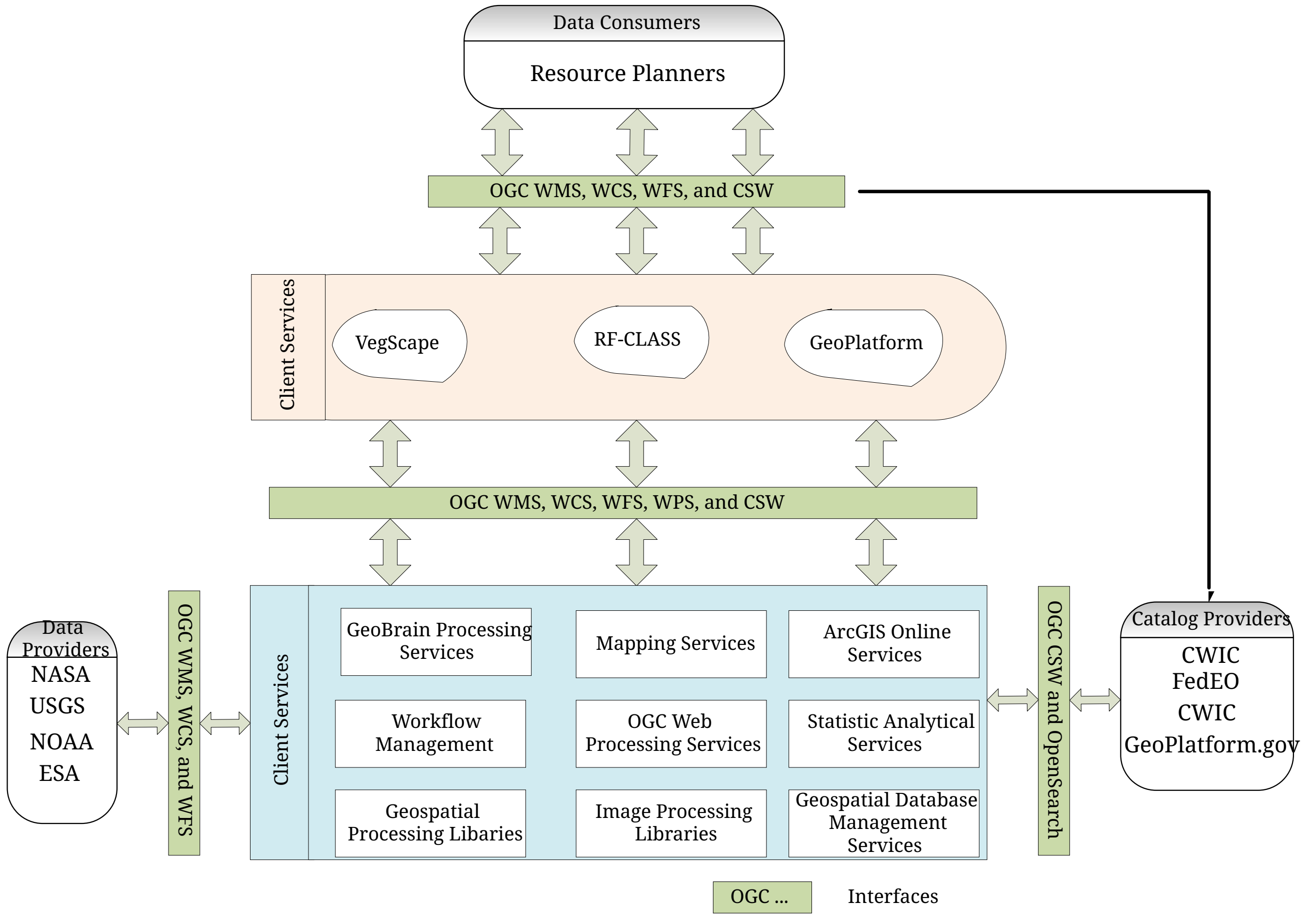

Figure 2. Software stack for Client Applications

2.1. Data Provider

Major data providers are as follows:

- National Aeronautics and Space Administration (NASA): NASA is the source for several types of satellite data, including Moderate Resolution Imaging Spectroradiometer (MODIS), Joint Polar Satellite System (JPSS) (the predecessor of NOAA-20).
- United States Geological Survey (USGS): USGS is one of the primary sources for land process products derived from remote sensing data, including derived products from MODIS and Landsat.
- National Oceanic and Atmospheric Administration (NOAA): NOAA is one of the main agencies in producing continuous weather-related products. Several high temporal resolution satellite sensors and their data are processed and archived at NOAA data service centers, including NOAA-20 and Geostationary Operational Environmental Satellites (GOES). Onboard NOAA-20, Visible Infrared Imaging Radiometer Suite (VIIRS) is considered as the operational continuity sensor of MODIS. It provides moderate spatial resolution data of similar spectral radiometric resolutions.

- European Space Agency (ESA): ESA is an intergovernmental agency that manages several satellite programs. Sentinel-1 (A/B) provides Synthetic Aperture Radar (SAR) data in high resolution in terms of spatial and temporal ranges.

2.2. Catalog Providers

Major catalogs are as follows:

- Committee on Earth Observation Satellites (CEOS) Working Group on Information Systems and Services (WGISS) Integrated Catalog (CWIC): CWIC is a federated, comprehensive Earth Observation catalogue that provides standard OGC catalogue service interfaces - OGC Catalogue Service for the Web (CSW) Dublin core, CSW ISO profile, and OpenSearch. It establishes live links to Earth observation data centers worldwide. Users can achieve one search that reach multiple data centers and back-end catalogues.
- NASA Common Metadata Repository (CMR): CMR is a comprehensive metadata system for all data and service metadata for NASA's Earth Observing System (EOS) Data and Information System (EOSDIS). It also functions as the International Directory Network (IDN) of CEOS to provide catalogue, maintain, and discovery of Earth Observation (EO) data of CEOS.
- FedEO (Federated Earth Observation missions access): FedEO is a large catalogue that is operated by ESA. Together with CWIC, it form one of the core component aggregate catalogs under CEOS.
- AmeriGEOSS Data Hub: AmeriGEOSS is a regional GEOSS (Global Earth Observation System of Systems) for continent of America. It provides discovery and access to data, tools, services and resources for Earth Observations in American continent. The Data Hub is made available through the Comprehensive Knowledge Archive Network (CKAN). It currently hosts more than 440K data/services/tools.
- GEOSS Registry: GEOSS Registry (http://geossregistries.info/)registers components, services, and resources as one catalog within GEOSS. Services and resources can be found in the registry.

2.3. Data Consumers

Resource planners are the primary user groups for all the scenarios to be demonstrated. Resources, in this context, are related to agriculture and cropland and their recovery.

All disasters may impact agricultural productivity. The extent and degree of impact are two of the most impact factors as resource planners efficiently allocate necessary resources for recovering and mediating the impact of disasters on agriculture.

Chapter 3. General Use Cases by User Activity

This section will provide details on the use case and end user.

3.1. Publication of data

Produce and publish the following data:

- Vegetation indexes from MODIS/VIIRS: Several vegetation indices are set up to be run in synchronization with the release of products. MODIS and VIIRS are chosen to calculate the indices considering their very high temporal resolution. The capability is part of VegScape. All results are published and served through OGC Web Map Service (WMS) and Web Coverage Service (WCS).
- Disaster Vegetation Damage Index (DVDI) from MODIS/VIIRS: DVDI is a newly developed index that represents the impact of disasters. DVDI for flood events is calculated and published as OGC WMS and WCS. They are part of capabilities of RF-CLASS.
- Flood extent map from Sentinel-1(A/B): A workflow using SAR data to derive flood extent is set up to be run event by event where the data from Sentinel-1 constellation become available. Data are published as OGC WMS and WCS services.
- Soil-moisture-saturated area map from SMAP: A model to extract soil moisture saturated area from SMAP was implemented and used to extract soil moisture saturated areas for declared hurricane events and their landfall track. This capability is part of RF-CLASS. All data are published and served through OGC WMS and WCS.
- Crop condition assessment: A series of crop condition indices were also calculated from vegetation index maps derived from MODIS/VIIRS. These include VCI (Vegetation Condition Index), RVCI (ratio of VCI to past year or past five years), and MVCI (deviation to normal or mean VCI). These indices reflect crop conditions against reference "norms" which serves as a set of good indicators for crop condition changes between disaster-affected and normal periods. All maps are published as OGC WMS and WCS.

3.2. Registration of data

Register the maps in the catalogs (CSW at GMU, CKAN and Geoplatform.gov)

- In this pilot, weekly products of normalized difference vegetation index (NDVI)) since 2008 have been registered in GeoPlatform.
- Series of flood extent maps derived from Sentinel-1(A/B) are registered in GeoPlatform and shared through a disaster pilot group on agriculture within GeoPlatform.
- DVDI WMS for selected flood events are registered in geoplatform.gov.
- A time series of saturated area maps derived from SMAP were registered in geoplatform.gov.
- Weekly Mean Vegetation Condition index (MVCI) since 2008 are registered in geoplatform.gov.
- All services are registered in the GEOSS Registry.

3.3. Discovering of data

The following catalogs are consulted to find relevant services and data:

- CWIC
- GEOSS Registry
- FedEO
- AmeriGEOSS Data Hub
- NASA CMR/IDN

3.4. Downloading of data

Access data through standard interfaces. The following data interfaces are primarily used in downloading products.

- OGC WMS for rendering and Web-based visualization
- OGC WCS for raster-based data access
- OGC WFS for vector-based data access

3.5. Data Integration

Integration of data with human-dimension data sources to relate the disaster impacts to resources - people, crop, and farms.

3.6. Republication of data

Publish the integrated results as standard geospatial services (WMS, WCS, and WFS) and register into catalogs:

- Web-based applications: VegScape is hosting and delivering crop conditions and related products. Standard OGC Web services are provided for user to access them through their own applications. Maps of hydrology and human dimensions (Census data with TIGER Line map) are integrated for user to select and extract data based on administrative regions - county, state, region, or agricultural statistic district (ASD). User can upload their own maps for area of interests (AOI) to derive special region map. Statistics can be generated on-the-fly and made available through spreadsheet data or charts. Similarily, RF-CLASS hosts all flood-related data. Hurricane-related soil saturation maps are also made available through RF-CLASS. Similar functions and automation capabilities are supported with RF-CLASS.
- Crop condition with human dimension resources: Story maps and series of maps are produced using ArcGIS Online (AGOL) and shared through GeoPlatform.
- DVDI with human dimension resources: Flood-event based DVDI maps are embedded in a story map using AGOL and shared through GeoPlatform.
- Soil-moisture-saturated map with human dimension resources: A series of soil-moisture-saturated maps are created using AGOL and shared through GeoPlatform.

3.7. Displaying of the data with proper symbology

Interactively produce the maps for resource planners on demand with their specific areas of interest and summation levels. OGC Styled Layer Descriptor (SLD) was used in defining and rendering different maps. They are released through OGC WMS.

3.8. References

- USDA, CropScape, URL: https://nassgeodata.gmu.edu/CropScape
- GMU, VegScape, URL: https://nassgeodata.gmu.edu/VegScape
- GMU, RF-CLASS, URL: https://dss.csiss.gmu.edu/RF-CLASS
- USGS, GeoPlatform, URL: https://geoplatform.gov
- GMU, GEO
- USGS, AmeriGEOSS Data Hub, URL: https://data.amerigeoss.org/

Chapter 4. Special Topics

This section will provide a description of the following special topics.

- Data customization - right data for the right user
- Themed map sharing - story maps

4.1. Right data for the right user

When registering the data products in a catalogue, tagging the data with proper themes and topics would greatly enhance the chance of finding the correct data by the right user. When users find the data, they may special requirements on areas of interest, temporal ranges, aggregation of information, and format of presentation. These special requirements can be accommodated by refined definition of styles, projection, or format in output. In VegScape and RF-CLASS, specialized on-demand customization is supported with OGC standard encoding schema. For example, area of interests can be uploaded by users if they provide maps in OGC standard formats - Geography Markup Language (GML) or GeoJSON. In Figure 3, a GML file was uploaded and used as area of interest to compute the statistic summary.

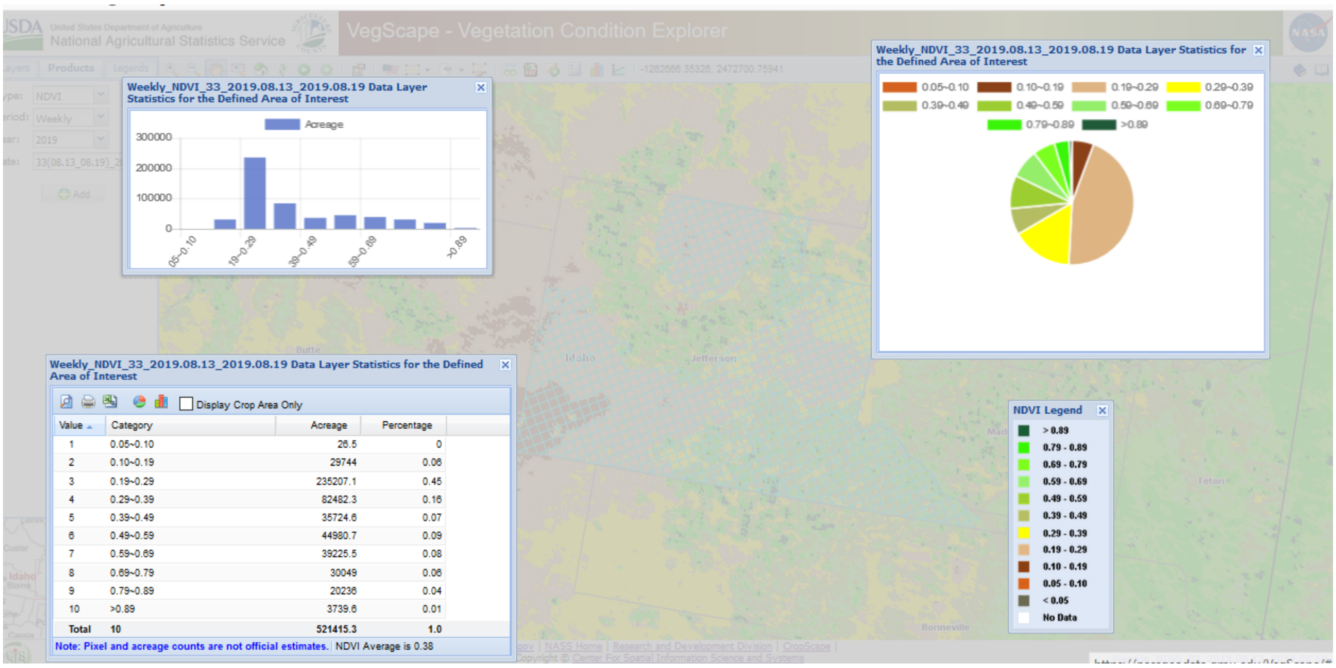

Figure 3. Customization of Data Summation and Retrieval by User-Uploaded-Area-of-Interest in GML

4.2. Story Maps

OGC WMS services can be re-used in many Web-based content creations. One example for flooding events, a series of themed maps can be created and linked together through a story line. The page can be released as a standard Web page to be shared in the Web, including the geoplatform.gov. In Figure 4, a flood event, in Houston, TX during Harvey, is described with interactive maps. The first map in the series is a map with swiping bar to compare before two different period during the flood events.

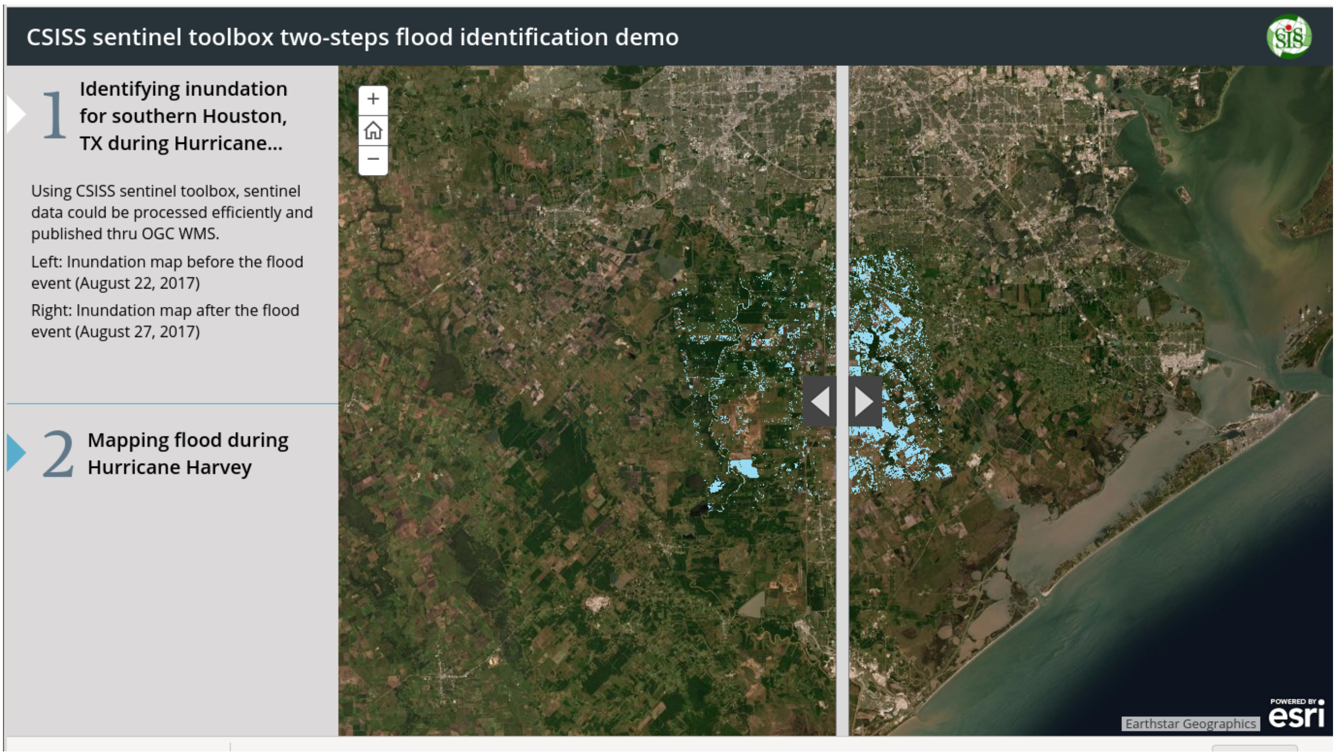

Figure 4. Example Content of Story Maps Created with Standard OGC Web Map Services

Chapter 5. Scenarios and Tools Demonstration

This section provides a detailed description of the scenario(s) and the description of the tools used in the demonstration. Three scenarios are described. They are flood, hurricane, and agriculture and food security. The section covers each scenario with audience, publication of data, registration of data, discovering of data, retrieval of data, data integration, republication of data, and rendering data with proper styles.

5.1. Flood

One flooding event caused by Hurricane Harvey was used to demonstrate the process and the use case. The Hurricane Harvey was declared as a FEMA disaster event DR-4332. The event peaked around August 25, 2017. It was reported that about 28 counties of Texas state were directly affected.

5.1.1. Audience

The audience is for resource planners who need the impact assessment information to make decisions in respond to flood events. Resource planners can be decision makers in public sectors (e.g. resource manager of Houston local government aid agency).

5.1.2. Publication of data

The flood scenario has intermediate model data to be produced and published.

5.1.2.1. In-situ Data

Validation data are collected from online resources and relevant websites. No re-publication is applicable.

5.1.2.2. Model Data

Calculation of vegetation indices are the base for calculating DVDI. Three intermediate model products are produced using NDVI products of MODIS or VIIRS.

- Product VCI:

VCI=(NDVI - NDVI_min)/(NDVI_max - NDVI_min)

where, NDVI is normal difference vegetation index which is produced daily, NDVI_min is minimum NDVI since 2000 at a given location, and NDVI_max is maximum NDVI at a given location.

- Product mVCI:

mVCI=(NDVI - NDVI_m)/(NDVI_max - NDVI_m)

where, NDVI_m is median NDVI since 2000 at a given location.

- Product DVDI:

DVDI=mVCI_a - mVCI_b

where, mVCI_a is the value of mVCI before a flood event and mVCI_b is the value of mVCI after the flood event.

All three products published through OGC WMS and WCS.

5.1.2.3. Remote Sensing Data

These products include Landsat, MODIS, and their products from USGS LP DAAC, VIIRS from NASA and NOAA.

5.1.3. Registration of data

Three intermediate model data are registered into the catalogue service at GMU. Resources can be found through RF-CLASS.

5.1.4. Discovering of data

Search the following catalogue for Sentinel-1 (A/B):

- CWIC
- FedEO
- NASA CMR/IDN (collection level)

5.1.5. Downloading of data

A set of scripts were developed to support the downloading of data from different servers in bulk. These can be adjusted to retrieve data from different types of servers. Standard OGC WCS and WFS are among the easiest to establish handshaking between applications and servers.

5.1.6. Data Integration

Two ways of integration and generation of information products were made available and exemplified. They are as follows.

- Production of flood extent maps from SAR data: The workflow is shown in Figure 5. The process can be automated with timely searching and analyzing responses from the catalogs, especially FedEO. Once a new data become available in an area of interest, the workflow can be triggered to produce flood extent maps.

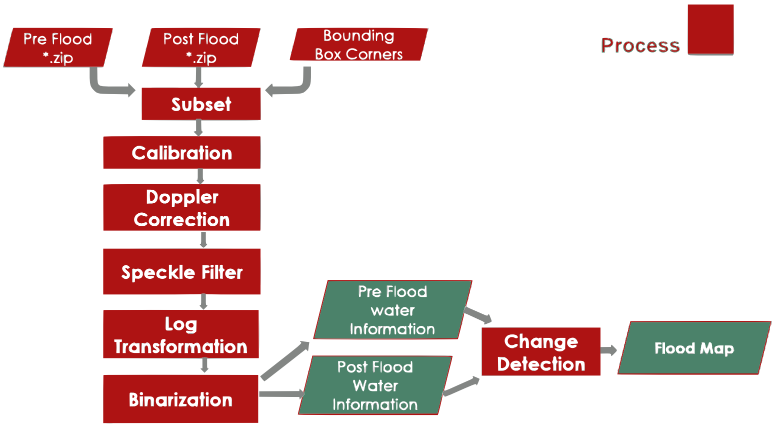

Figure 5. Data Processing Processes and Production of Flood Extent Map

The high spatial resolution is critical for emergence response as rescue team need to know inundate situation so they could plan route in advance for resource delivery.

One example case was run with the workflow for the Hurricane Harvey 2017 that directly landed around Houston, Texas. The result is presented as a story map exhibited through ArcGIS Online (AGOL). The story map can be found in geoplatform.gov . The direct link to the use case for the scenario can be navigated to is as follows: https://www.geoplatform.gov/resources/applications/8d5f2bb5033484e21f0468f64fcdc10c/ . Comparing the inundated areas before Hurricane Harvey on August 22, 2017 and after Hurricane Harvey on August 27, 2017, we can clearly define the flooded area as shown in Figure 6 .

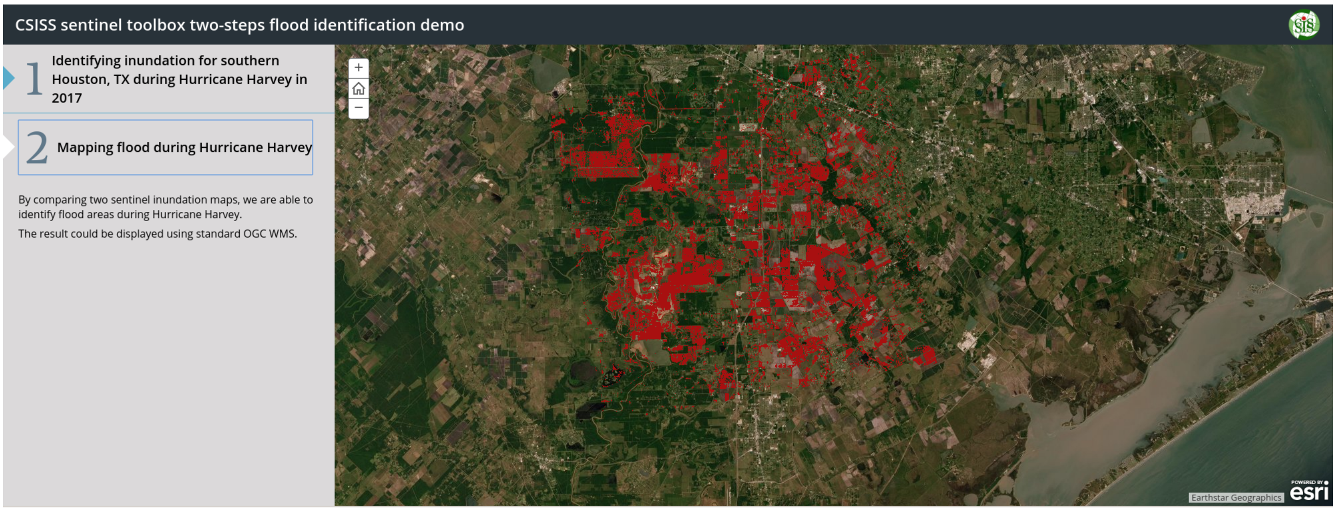

Figure 6. Flood Extent Map of Suburban Area in Houston, Texas during Hurricane Harvey, 2017

- Integration of flood extent map, DVDI, and human dimension data:

The flood extent and impact maps (e.g. DVDI) can be integrated with human dimension data to get the estimate on how many people are affected by what degree. This can be done automatically in RF-CLASS if user provide the human dimension data.

In geoplatform.gov, the analysis can be done with AGOL and the results can be shared through the connection between GeoPlatform and AGOL. In the example of flooded areas caused by Hurricane Harvey in 2017, a series of human dimension maps can be overlayed and union with DVDI and/or flood extent map. For example, population or special group of population - e.g. senior population density map be unioned with flood extent and DVDI to give an estimate report on the number of people (or senior people) and the degree of impact in a given area. The DVDI map for suburban area of Houston during the Hurricane Harvey in 2017 is shown in Figure 7. The population density map of suburban area of Houston in 2017 is shown in Figure 8. The senior population density in the suburban area of Houston in 2017 is shown in Figure 9.

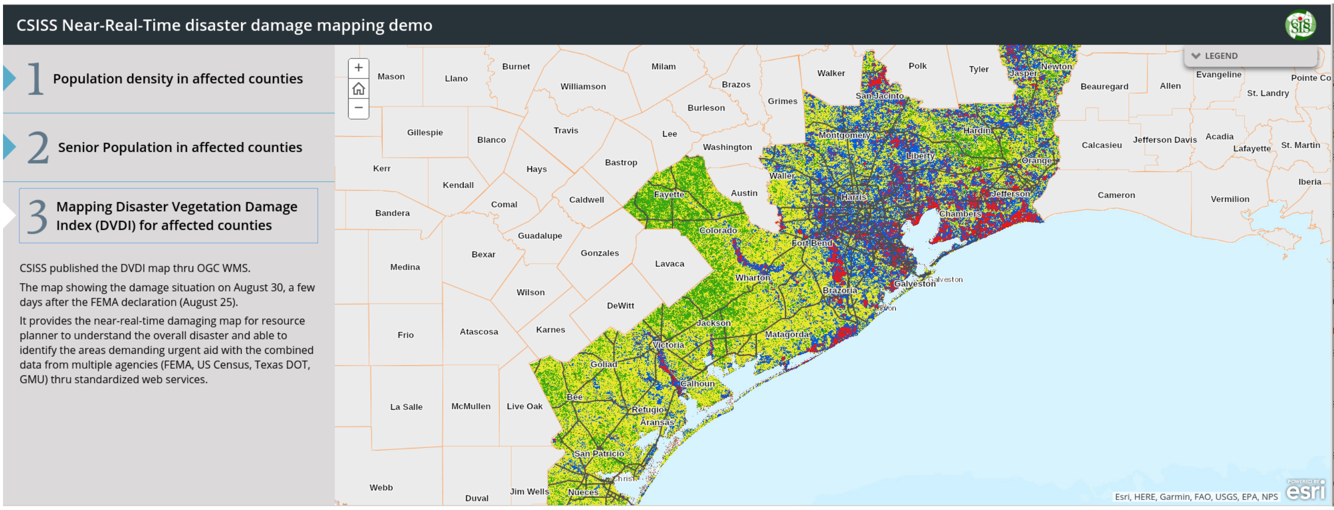

Figure 7. DVDI of Suburban Area in Houston, Texas during Hurricane Harvey, 2017

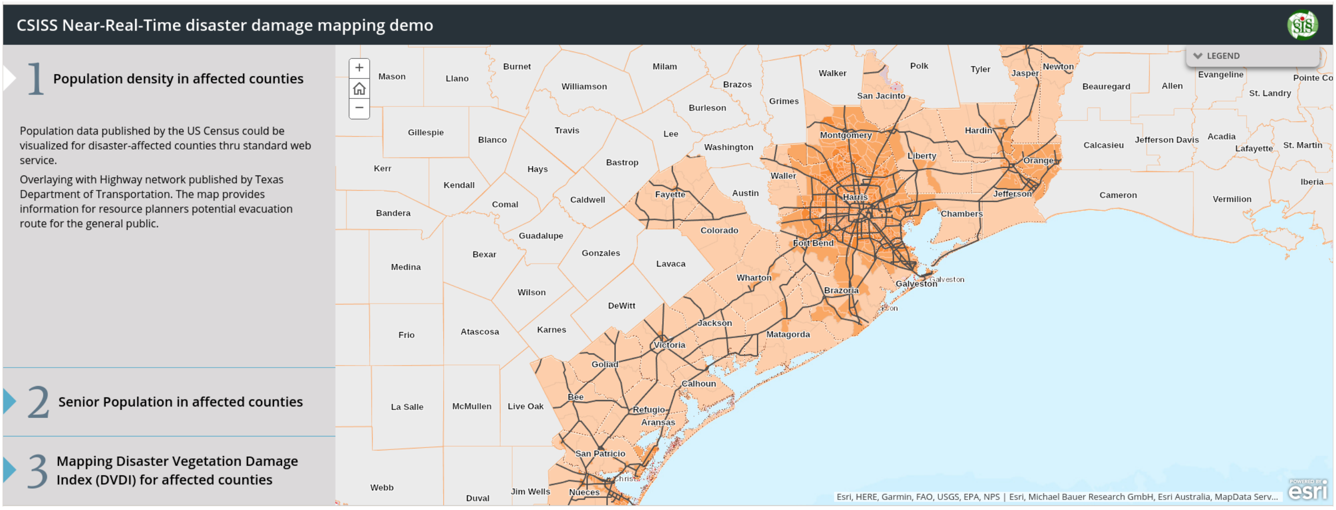

Figure 8. Population Density of Suburban Area in Houston, Texas during Hurricane Harvey, 2017

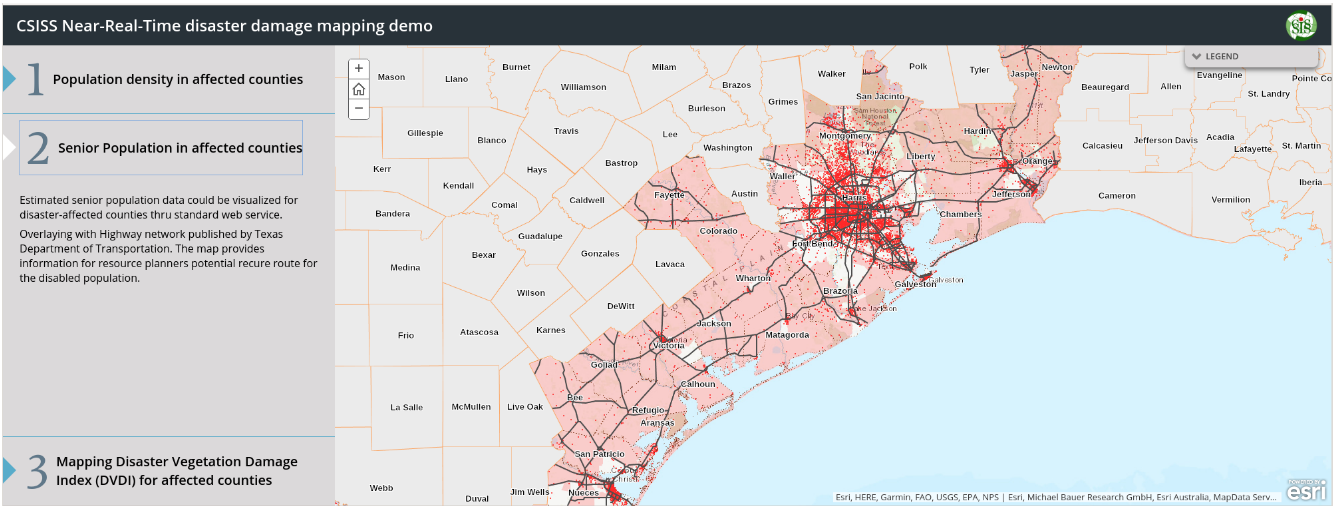

Figure 9. Senior Population Density of Suburban Area in Houston, Texas during Hurricane Harvey, 2017

5.1.7. Republication of data

The republication of results is made available through two channels:

- RF-CLASS manages flood event by event. Relevant products are stored and managed in one place for easy retrieval, summation, and visualization.
- Register the results into GeoPlatform as a service or a dataset. Another route is to share the maps through AGOL using OGC WMS or WCS services.

5.1.8. Displaying of the data with proper symbology

Rendering and styling can be defined with OGC Styled Layer Descriptor (SLD) through combination of OGC WFS and WMS services.

5.2. Hurricane

The Hurricane Harvey was used an example to showcase how the tools and geospatial Web services can be used to help resource planners to quickly get an idea of affected areas by Hurricane.

5.2.1. Audience

Resource planners are the primary audience for this use case. Stakeholders related to agriculture sectors such as farmers, researchers, agriculture traders, and insurance planners can use this system for the information on the possible impact of hurricanes on crops.

5.2.2. Publication of data

5.2.2.1. In-situ Data

No specific in-situ data are used. Soil moisture data from other sources with similar scale may be used for validation.

5.2.2.2. Model Data

The soil moisture saturated areas are detected and extracted from soil moisture data of SMAP. Figure 10 shows the detection algorithm.

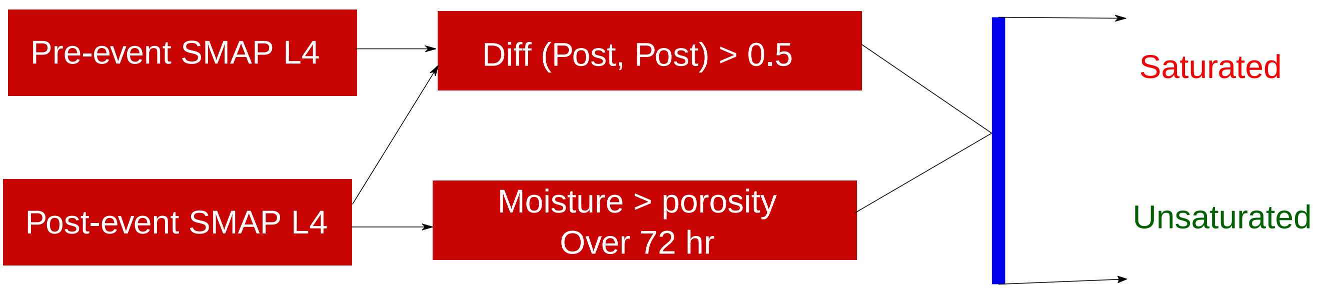

Figure 10. Soil Moisture Saturation Area Detection Algorithm from SMAP

5.2.2.3. Remote Sensing Data

This submodule uses SMAP soil moisture data product as the base to derive soil moisture saturation map.

5.2.3. Registration of data

The OGC WMS services of soil moisture saturated area data are registered in GeoPlatform.

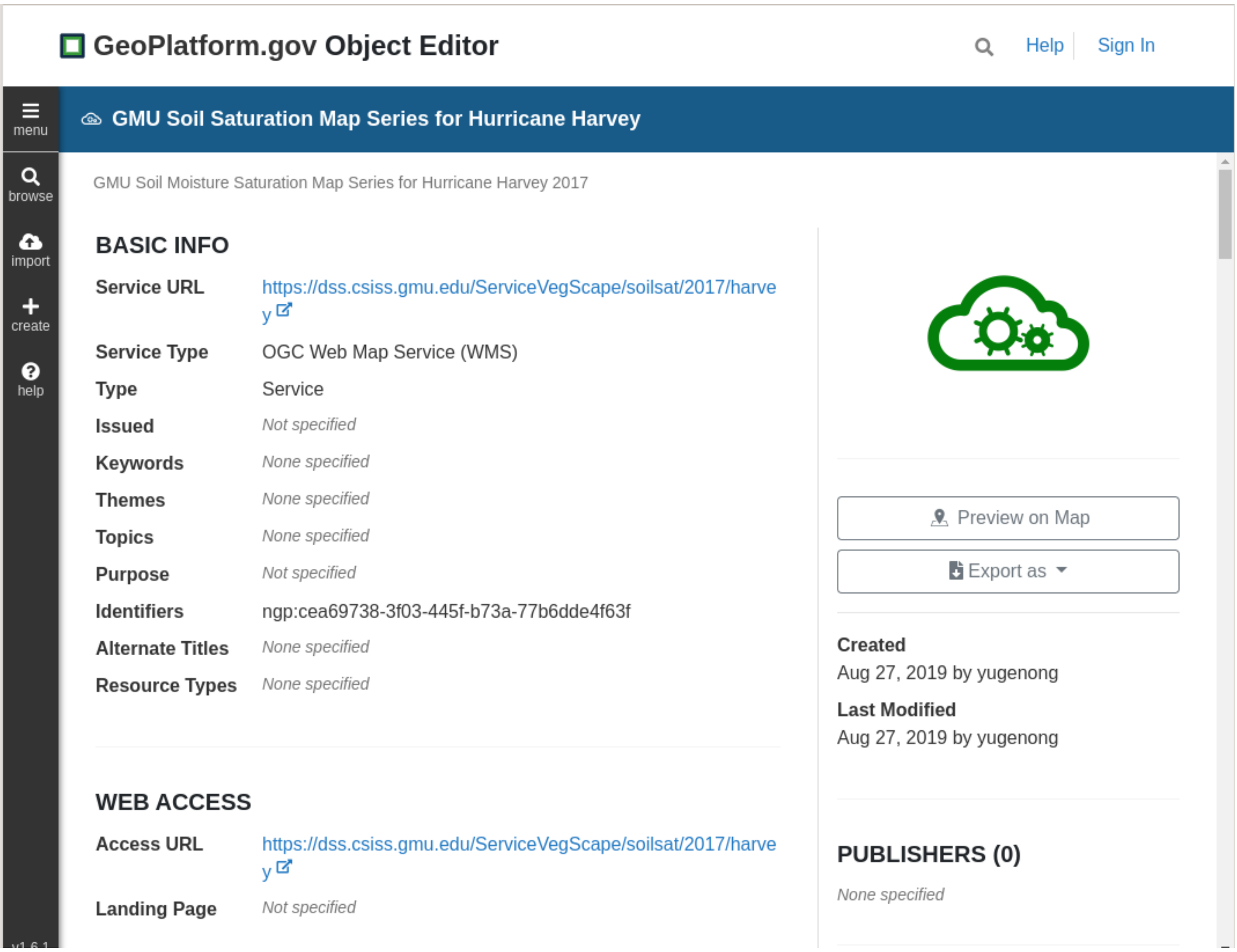

Figure 11. Registered Soil Moisture Saturation Map in GeoPlatform

5.2.4. Discovering of data

Search of related data can be done with the following catalogue:

- NASA CMR/IDN: Search SMAP granules.
- GeoPlatform: Search other shared map and data.
- RF-CLASS: Search event-based soil moisture saturated area maps and data.

5.2.5. Downloading of data

Data download and use can be done through the following wasy:

- Download through standard OGC Web services, e.g. WCS, WFS
- Download through ordering or direct downloading services.
- Direct use of the service link in Web content creation.

5.2.6. Data Integration

There are two ways of data integration with other data layers to analyze and summarize the data against direct groups by fields. One is using the pre-defined functions in RF-CLASS that is capable of overlaying and analyzing standard WMS or WFS result with standard GML or GeoJSON layers. The GML layer can be defined by selecting certain administrative areas. The aggregation and summation can be completed against these areas. Their attributes can be used in grouping and summation. By doing so, approximated affected area by hurricane landfall can be quickly reported by different fields, such population, household.

Another general approach is import the data into another analytical system, such as AGOL, through standard OGC interface (e.g. WMS or WCS) for summation and aggregation. [igure_of_architecture_hurricane] shows the overall process of producing soil moisture saturation maps and their integration with alternative systems for retrieving and estimating impacted areas.

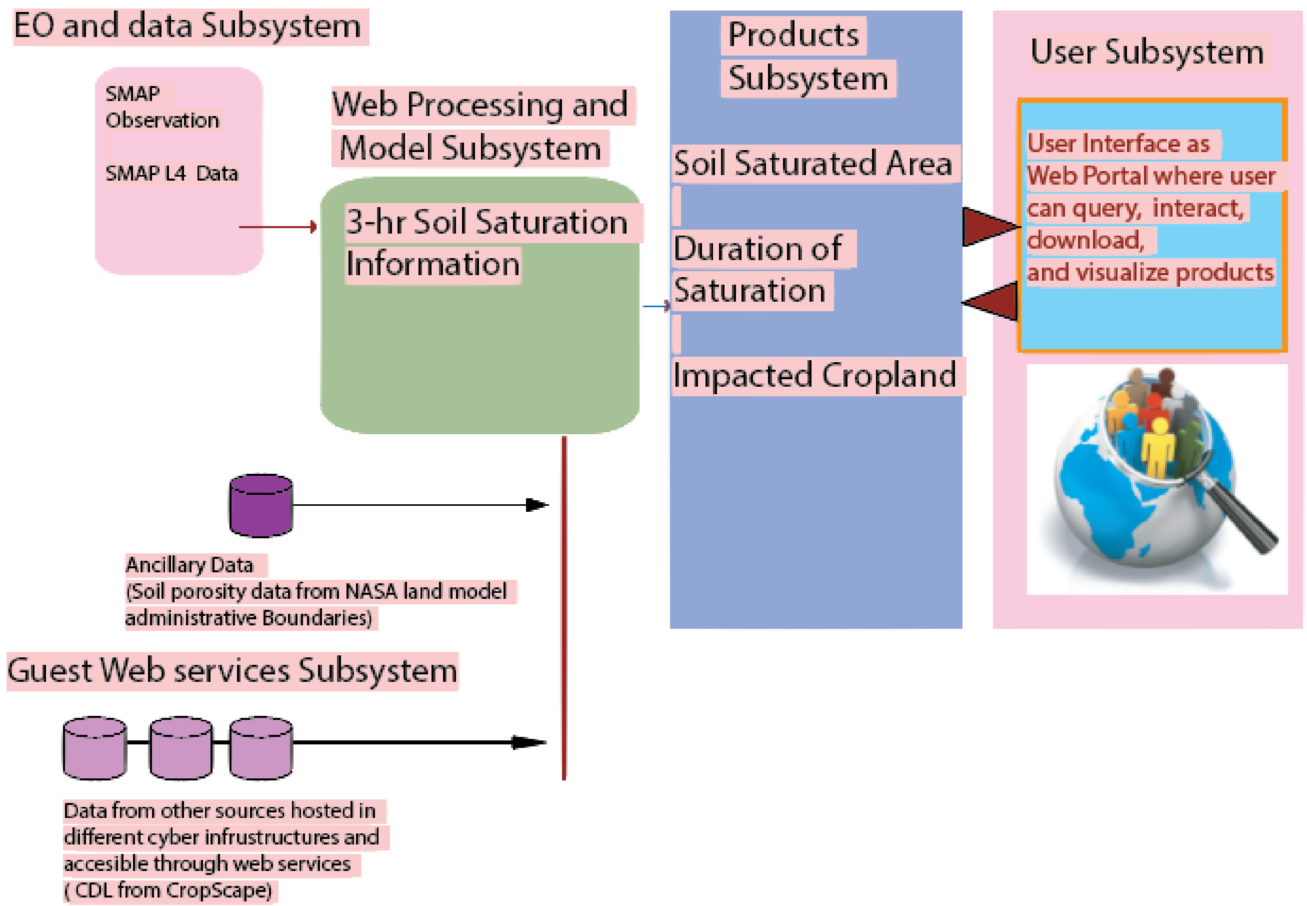

Figure 12. Processing Processes and Data Integration to Produce Soil Moisture Saturation Maps

5.2.7. Republication of data

The results can be published as a map in OGC WMS or a dataset in OGC WCS.

5.2.8. Displaying of the data with proper symbology

The resulted soil saturation area map can be displayed and re-used in other systems. The map is served through OGC WCS for original data access and WMS for rendering in the Web. Figure 13 shows a time series of soil moisture saturation map that captures the landfall of Hurricane Harvey around Houston area. Figure 14 shows one example rendering and mapping using the soil moisture saturation maps registered in geoplatform.gov. The OGC WMS service can be accessed ans used as a layer and its style can be adjusted to fit with the overall map.

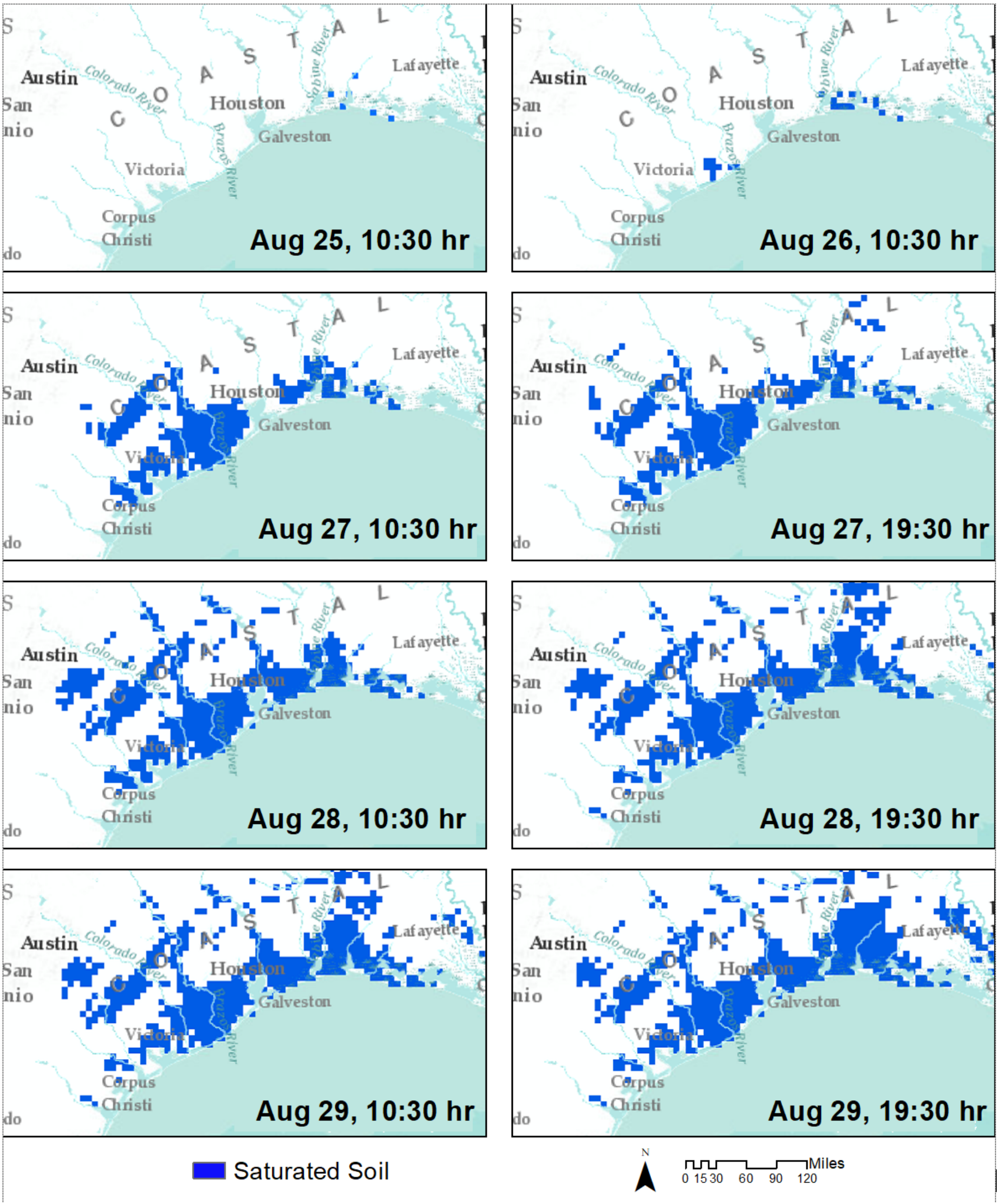

Figure 13. Time Series of Soil Moisture Saturation Maps for Hurricane Harvey, 2017

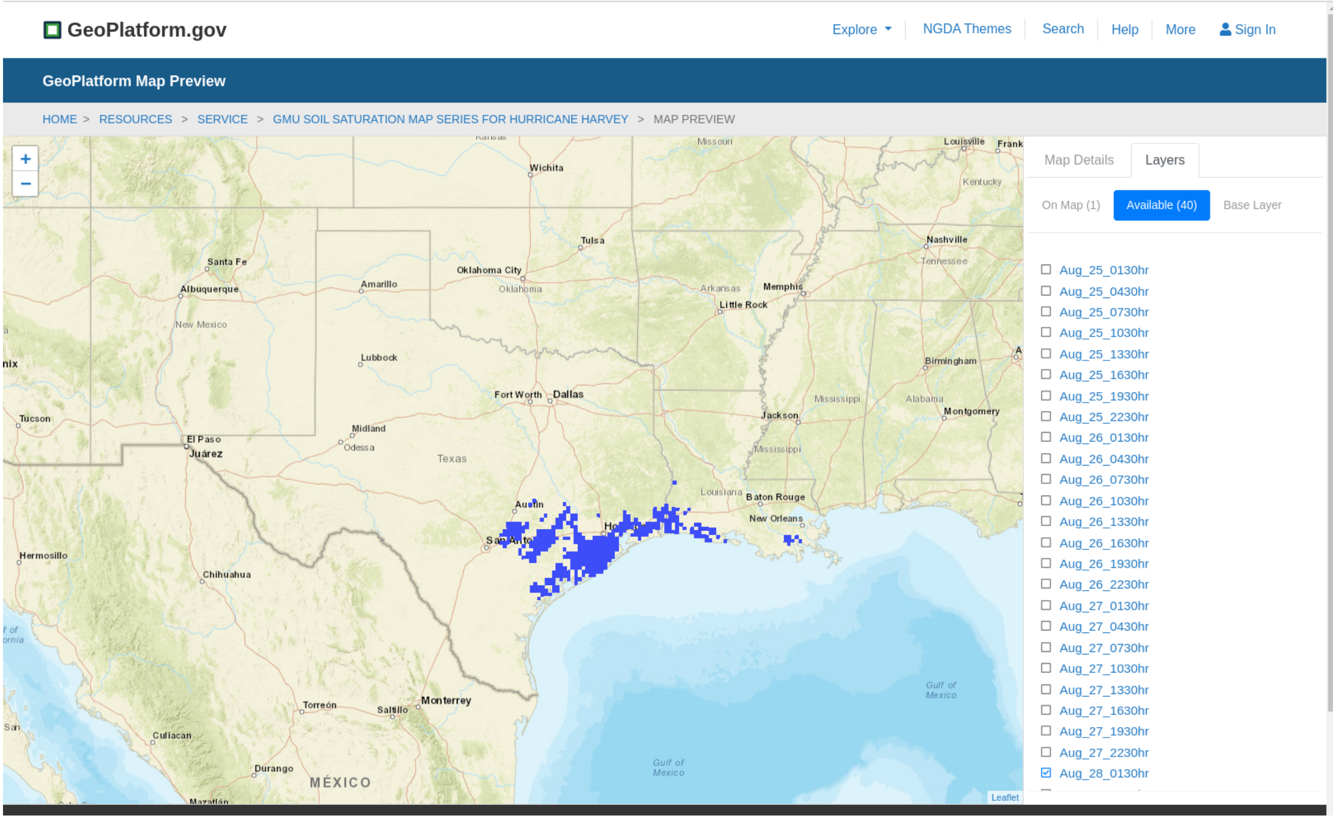

Figure 14. An example of Using and Rendering Soil Moisture Saturation Map in GeoPlatform.gov

5.3. Agriculture and Food Security

The suite of tools and geospatial Webservices enable the quick estimate of severe weathers' impact on agricultural productivity. In this pilot, two demonstration cases were selected to represent two types of weather extremes that have significant impact on agricultural productivity. One is severe storms that cause innundation and direct damage of crops. The latest declared severe storm event in 2019 is FEMA DR 4451 - Missouri Severe Storm lasting between April to July 2019. Another is drought. One of the historical droughts, happened in 2012 that affected most of the North America, was used to demonstrate the usage.

5.3.1. Audience

Resource planners are the targeted users of the impact assessment results. Resource planners who have a concern on efficiently allocating resources to aid the affected farmers and cropland shall use the rapid assessment results to guide them to make informed decisions.

5.3.2. Publication of data

Several products of crop conditions are published as OGC WMS for rendering and WCS for data access. They are registered into VegScape as well as geoplatform.gov.

5.3.2.1. In-situ Data

Filed data are required for calibration, validation, and verification of the vegetation-index-based yield estimation models. These data need to be up to field-level. Most of the validation data are indirectly collected through analyzing reports of seed companies and fertilizer companies who post sample field level data online.

5.3.2.2. Model Data

Five crop condition indices are calculated using very high temporal resolution MODIS and/or VIIRS data. The model can be found in the help file of VegScape. The results are made available through OGC WMS and WCS.

5.3.2.3. Remote Sensing Data

Primarily, two sources of satellite observations are used. They are MODIS and VIIRS. Both are used for continuity. They have moderate spatial resolution while very high temporal resolution which is crucial for crop monitoring and condition estimation.

5.3.3. Registration of data

Model results are registered and shared through VegScape and GeoPlatform.

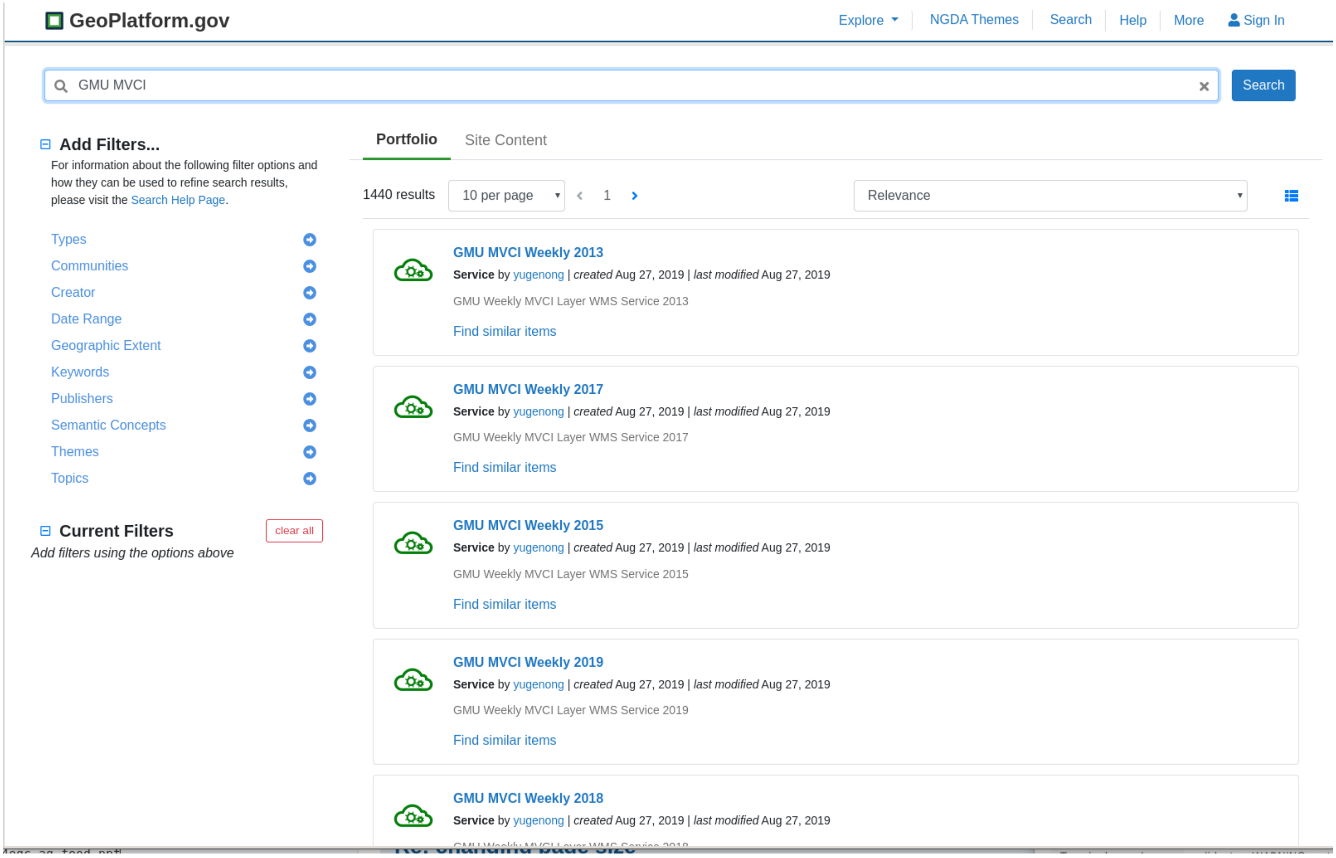

Figure 15. Search Registered Assets on Crop Conditions By GMU in GeoPlatform.gov

5.3.4. Discovering of data

The following catalogues are used in searching satellite observations, in-situ data, and model data.

- NASA CMR/IDN
- CWIC
- GeoPlatform.gov

5.3.5. Downloading of data

Standard OGC WCS and WFS services are preferred in accessing and feeding data into the workflow automatically. Major providers' secured downloading services are also used in automatical retrieval of data periodically as the new data roll in. This method of accessing data is true for NASA data providers.

5.3.6. Data Integration

Cropland data layer (CDL) from CropScape is used as the base for crop types. Social economic data are mainly ingested from sources based on TIGER Line geodatabase. Agricultural specific background data are accessed through the Quick Stats of USDA NASS. The layers are unioned to form a cross-reference geodatabase which enables the summation by different attributes. Acreages of different cropland in a defined area of interest (e.g. county, state, region) can be summarized and reported in forms of tables, pie charts, or charts.

5.3.7. Republication of data

Maps and results are accessible through VegScape using OGC WMS or WCS services. Figure 16 shows one example NDVI-with-county-level-attribute product published as an OGC WFS and WMS service in VegScape. They are also registered into geoplatform.gov for sharing and re-using.

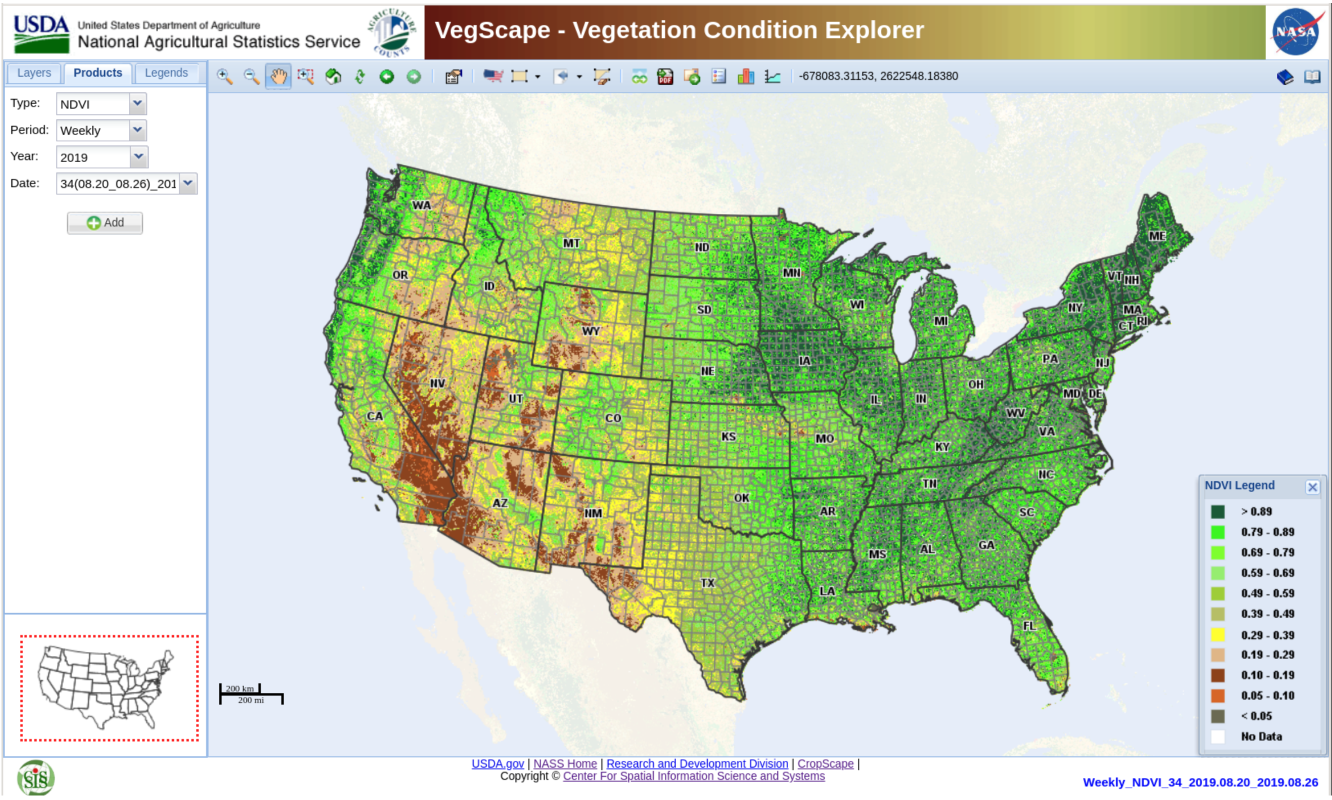

Figure 16. Published NDVI Data in VegScape

5.3.8. Displaying of the data with proper symbology

The visualization and display of results include several forms. Maps provide direct visualization as well as further aggregation and summation. For example, during the Missouri Severe Weather Storm event, the difference of disaster-affected crop conditions can be seen in maps of different indices as shown in Figure 17. The damaged cropland shows a significant drop of crop condition indices comparing to that of the same season in normal (no-disaster) year. Stats and summation can be produced with different administrative areas or user-uploaded-area-of-interests. Figure 18 shows summation by crop conditions.

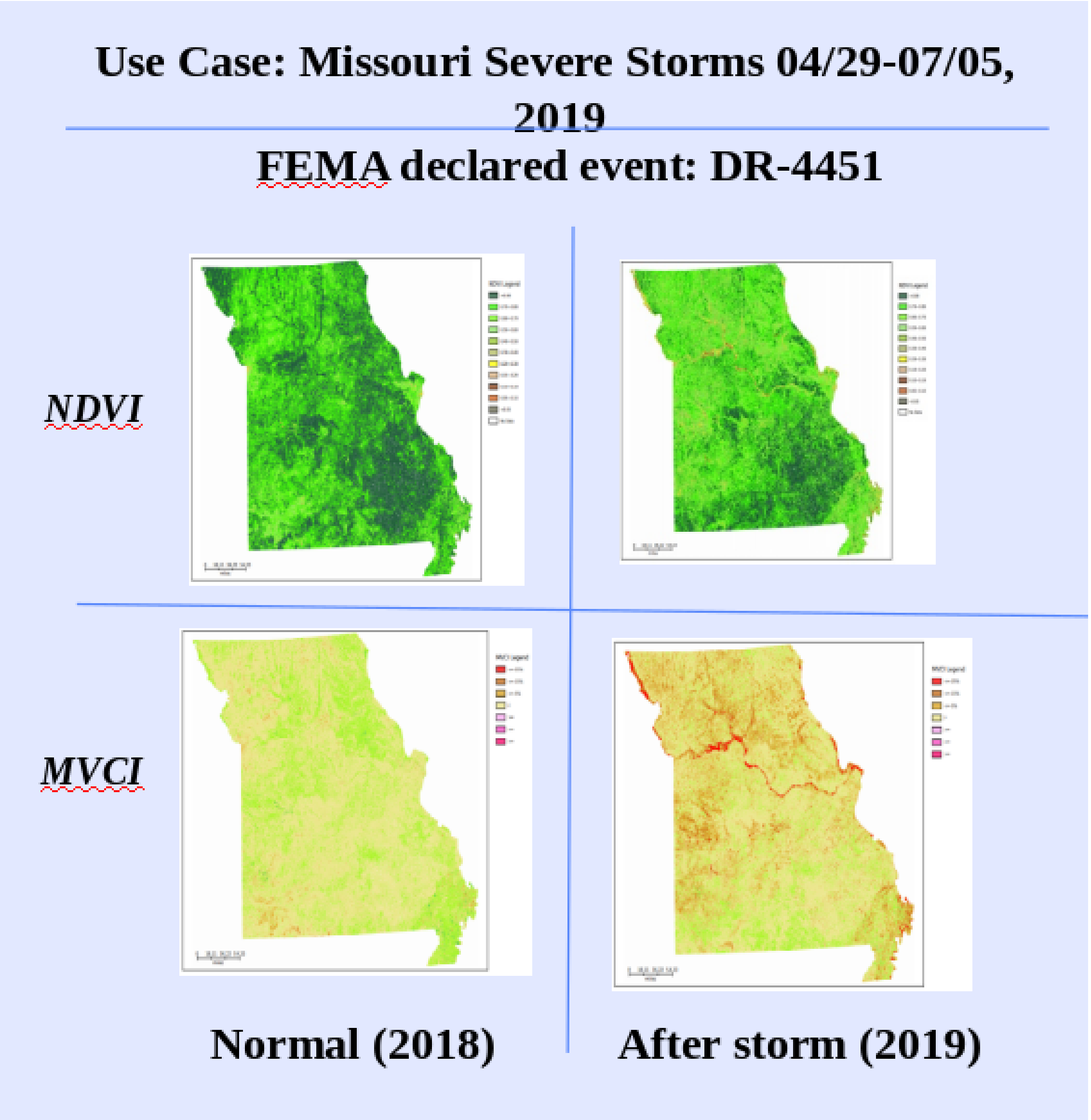

Figure 17. Deviation from Normal Crop Conditions - Severe-Storm-Impact

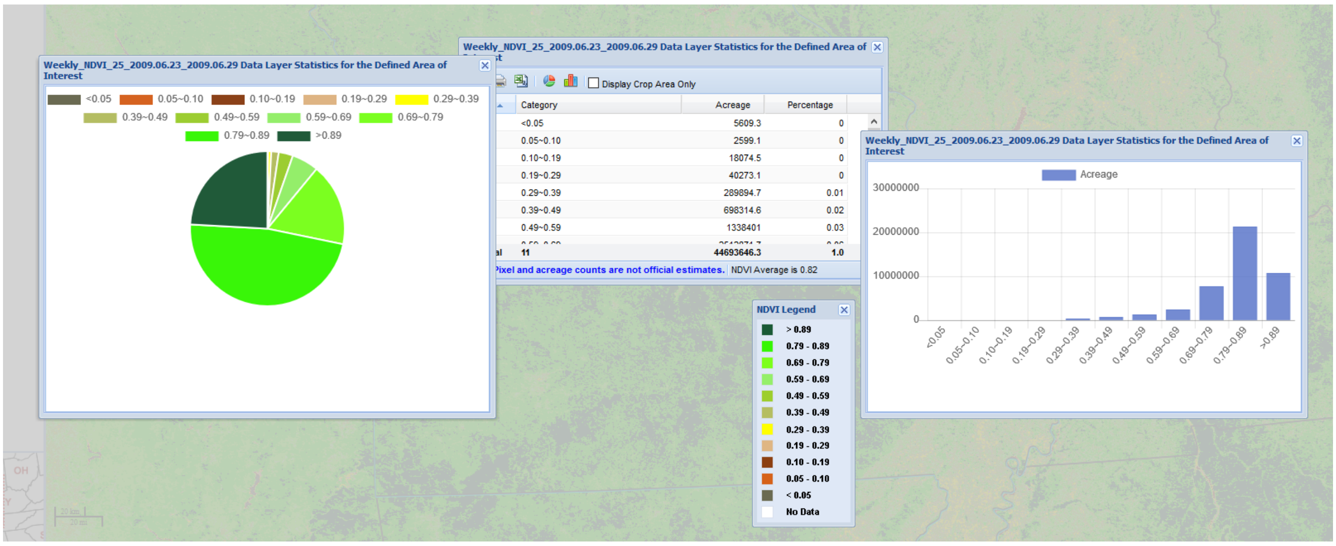

Figure 18. Stats and Summation of Cropland By Crop Conditions

Figure 19 shows the drought impact in Kansas state during the severe drought peaked at August, 2012 that affected most of the North America.

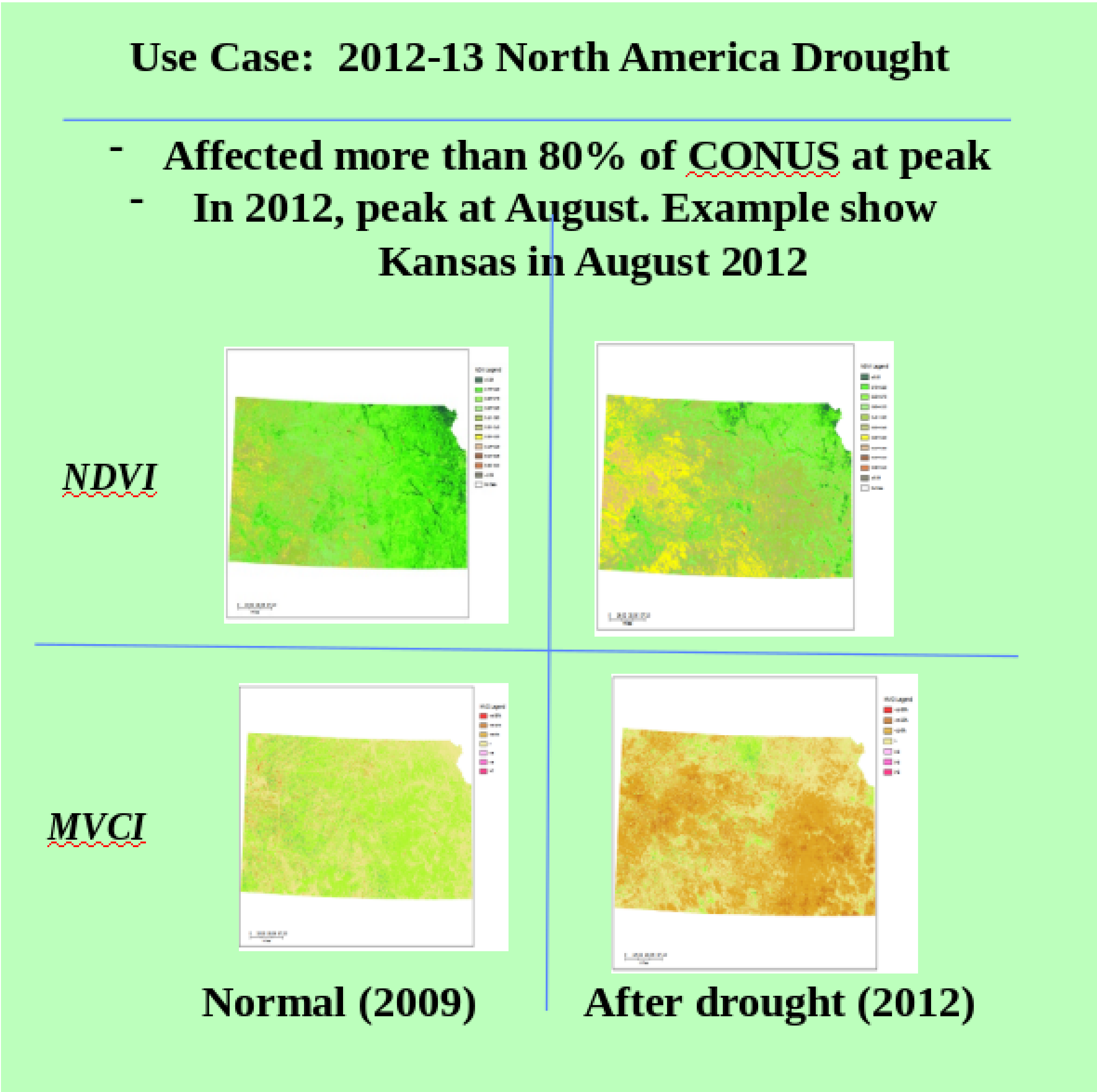

Figure 19. Deviation from Normal Crop Conditions - Drought-Impact

The crop condition maps can be found and used to create maps within geoplatform.gov. Figure 20 shows one example map created and rendered by searching the registered GMU crop condition dataset and services.

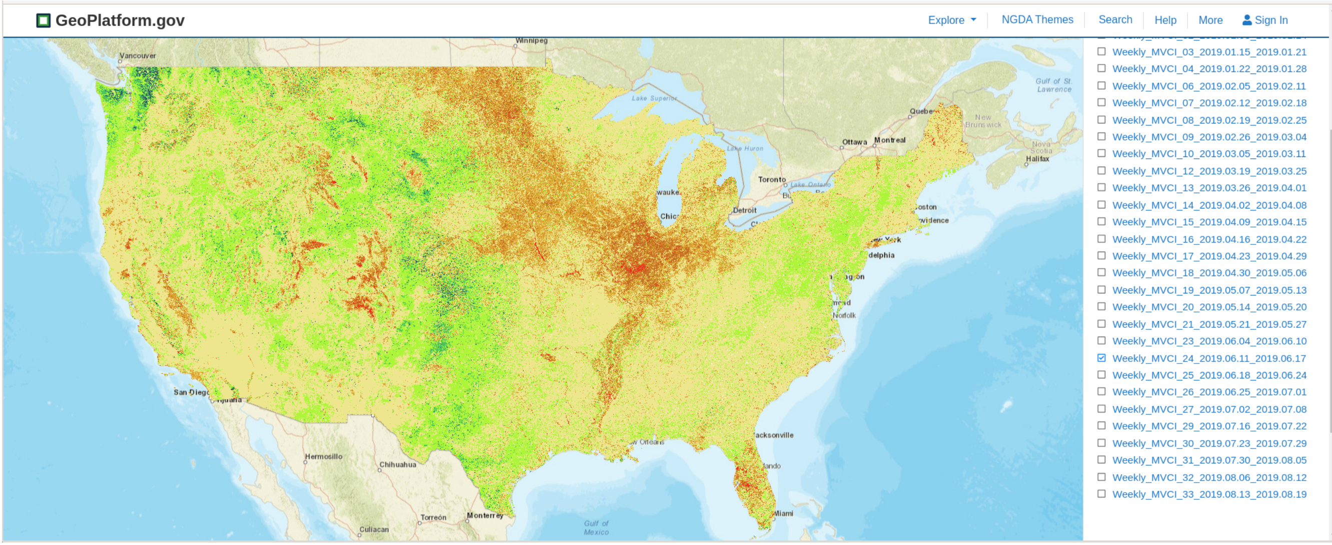

Figure 20. Creating Crop Condition Map in geoplatform.gov

Chapter 6. Conclusion and Way Forward

Three scenarios, i.e. flood, hurricane, and agriculture/food security, have been demonstrated by leveraging the geospatial Web technologies and OGC open geospatial standards. The pilot applications showed the improvements and extended accessibility and interoperability through open geospatial standards. Specifically, the following are the major findings:

- Flood scenario: Making objective decision on resources dissemination is only possible when there is data and the data is ready for resource planner to use. With using the powerful online GIS server – GeoPlatform. Data and method were able to be communicate and generate meaningful data for resource planner at right time. We hope this work could be utilized to reduce life and economic loss due to flood.
- Hurricane scenario: Soil moisture active passive (SMAP) level for users to monitor soil saturation during hurricane landfall. The duration of soil saturation can also be mapped using time series of 3-hrly saturation map. This duration can be helpful to estimate the potential impact on crop fields at any location. Since SMAP data are gathered using microwave sensor, the presence of cloud in the sky during hurricane landfall is not an issue for data gathering. Coarse spatial resolution (9km) of SMAP is the major drawbacks to use this data for soil saturation monitoring. More fine resolution data may help for better mapping. Combining data from different sources may be complicated for end-users to generate information they are looking for. A web portal consisting of all data they need may be helpful for the end-users.
- Agriculture and Food Security Scenario: Crop monitoring and related loss estimation require time series of data to be processed and produced. Data needs to be processed and disseminated periodically. Automation is needed on both processing and dissemination. The scenario application showed that OGC open specifications make it possible and easy to ingesting and disseminating data. WCS and WFS were successfully used in supporting data access and data distribution. WMS is well received in different infrastructures that facilitate the cross-platform sharing of visual maps.

Major issue identified:

- Projection handshaking of WMS: The use of Web Mercator Projection by default in clients with library like Leaflet may prevent WMS to be used if the WMS only defaults to support required EPSG:4326 without supporting EPSG:3857. Acceptance of different projection code may also cause problem. In the Leaflet-based GeoPlatform, EPSG:5070 is not recognized while EPSG:6350 is recognized, although they have the same parameters.