National Flood Interoperability Experiment

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Catchment-based Hydrological Data Assimilation (CAHMDA) VI Conference

8 September 2014
Overview: National Water Center (NWC)

- Located on Tuscaloosa Campus of University of Alabama

- Operated by National Weather Service to support IWRSS partners (NWS, USGS, Corps of Engineers, FEMA)
Integrated Water Resources Science and Services (IWRSS)

Aligns multiple agencies with complimentary water-related missions to:

• Integrate services and service delivery

• Improve river and flood forecasts

• Provide new summit-to-sea water resources analyses and forecasts

• Enable more effective use of resources

Roadmap Document (February 2009)

NWS River Forecast Centers

Perform precipitation, runoff and river flow simulation and forecasting for five days ahead, updated daily, more frequently during floods
Nationally Synthesize Operations of Regional River Forecast Centers
Inaugural Meeting – May, 2014
Overview: National Water Center (NWC)

- Operations Center with Situation Rooms - Temporal information
  - Establish common operating picture for floods to droughts; begin demonstration of hourly summit-to-sea analyses and forecasts of soil moisture, evapotranspiration, and snow pack; and expand demonstration of Real-Time Dynamic Flood Inundation Mapping portraying the extent, depth, and impacts of flood waters to enhance community resiliency and enable decision makers to mitigate the impacts of floods.

- Geo-Intelligence Laboratory - Geospatial information
  - Develop, implement and maintain state-of-the-science enterprise Geographic Information Systems (GIS) to support NWS operations

National Water Data Infrastructure
Transformative Research (NSF)

Transformative research involves ideas, discoveries, or tools that radically change our understanding of an important existing scientific or engineering concept or educational practice or leads to the creation of a new paradigm or field of science, engineering, or education. Such research challenges current understanding or provides pathways to new frontiers.

http://www.nsf.gov/about/transformative_research/definition.jsp

How to move from evolutionary change to transformative change?
National Flood Interoperability Experiment (NFIE)

- Will be led by the academic community in collaboration with the IWRSS partners through the National Water Center
- Run from September 2014 to August 2015
  - Preparatory phase to May 2015
  - Summer Institute at the National Water Center, June to August 2015
NFIE Goal: Connect National Scale Flood Modeling with Local emergency planning and response

1. How can near-real-time hydrologic simulations at high spatial resolution, covering the nation, be carried out using the NHDPlus or next generation hydro-fabric (e.g. data structure for hillslope, watershed scales)?

2. How can this lead to improved emergency response and community resilience?

3. How can an improved interoperability framework support the first two goals and lead to sustained innovation in the research to operations process?

Slide: Ed Clark, NWS
NFIE Academic Centers (as at present)

University of Illinois (Modeling)

University of North Carolina (Data)

University of Texas (Interoperability)

University of Alabama (Emergency Response)
NFIE: Proposed Timeline

- Aug ‘14: Flash Flood Summit at the NWC
- Sep: Hydro Domain Working Group
- Mid-Oct: Fall NFIE Meeting
- Jan ‘15: Spring NFIE Meeting
- Mar: Summer Institute launch
- May: Summer Institute capstone
- Jun: Summer Institute

Subcommittee on Spatial Water Data and Open Water Data Initiative

Slide: Ed Clark, NWS (pre-decisional)
Flood hydrology and response

Flood Inundation Maps

- Flood hydrology and hydraulic data, models, forecasts
- Flood emergency response planning and action

Forecast the flood elevation
Determine and plan for flood impact
Halloween Flood, Onion Creek, Austin, Texas, October 2013

Upstream watershed 280 mi$^2$ (larger than the City of Austin)

Watershed delineated using ESRI terrain services

A flooded home location
FEMA Flood Hazard Zone
## Mitigation and Response Flood Levels

### Mitigation (ft above NAVD88)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Stage Height</th>
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<tbody>
<tr>
<td>500 yr</td>
<td>490.34</td>
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<tr>
<td>200 yr</td>
<td>487.88</td>
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<tr>
<td>100 yr</td>
<td>484.82</td>
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<tr>
<td>5 yr</td>
<td>466.62</td>
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<tr>
<td>2 yr</td>
<td>460.30</td>
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</tbody>
</table>

### Response (Stage Height, ft)

- **Flood Stage:** 17
- **Moderate Flood Stage:** 20
- **Major Flood Stage:** 24
- **Action Stage:** 15
Real-Time Flood Inundation Mapping (USGS/NWS)

Use modeling to extend this concept to the whole country

NHDPlus
Geospatial base for National Water Data Infrastructure

NHDPlus
(built 2004-2014)

National Elevation Dataset

National Hydrography Dataset

3 million catchments
average area 3 km²,
reach length 2 km

Watershed Boundary Dataset

National Land Cover Dataset
Rapid Model for flow on NHDPlus
March to May 2008, 3 hour time steps

GIS data describes 1.2 million river reaches . . .
. . . simulate flow in each reach in each time step
Dynamic downscaling of NWS River Forecasts

NWS Flow Forecasts are “dynamically downscaled” onto the NHDPlus Catchments using the “RAPID” model.
Linking NWS Flood Forecasts to FEMA National Flood Hazard Layer

National Weather Service
River Forecast Subbasins

National Flood Hazard Layer

Intersect NHDPlus Catchments with Flood Hazard Layer to get a flood warning zone for each catchment
“Dynamic Downscaling” of NWS River Forecasts to NHDPlus for Onion Creek
Water Map and Data Services

RAPID Streamflow Calculations – 47 NWS River Forecast basins downscaled to 5,175 NHDPlus catchments in San Antonio and Guadalupe basins

https://ut-austin.maps.arcgis.com/home/webmap/viewer.html?webmap=d107aa9260534ddbb96db302e3643a93
Integration of Map and Data Services

Amazon Cloud (Map Services) → Web Viewer → MS Azure Cloud (Data Services)

Spatial Aggregation

Temporal Aggregation

Server

SQL Database
Open Geospatial Consortium
More than 400 companies and agencies globally

Internet standards for
Map services
Observation services
Catalog services
WaterML Web Services – CUAHSI, USGS, OGC, WMO …..

Water time series data on the internet

[Graph showing water flow data over time with marked discharge values]

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24/7/365 service
For daily and real-time data

… Operational water web services system for the United States

http://waterservices.usgs.gov/nwis/iv/?format=waterml.2.0&sites=08158000&period=P1D&parameterCd=00060
Water Data Distribution by US Geological Survey

NWISWeb and NWIS Water Services in Millions of Successful Page Requests

Web service requests (millions/month)

Web page requests (millions/month)
Open Water Data Initiative

- Subcommittee on Spatial Water Data will lead this effort
- This reports to both FGDC and ACWI

Chair
Anne Castle, Asst Secretary for Water and Science, Dept of Interior
National Flood Interoperability Experiment
Data Framework

Temporal

Time Series
(WaterML2 and .csv)

Multidimensional Arrays
(WCS and netCDF)

Geospatial

Hydrology
(RFC Basins, NHDPlus Catchments)

Hydraulics
(National Flood Hazard Layer, Flood Inundation Map Libraries)
Develop NWS Experimental Data Services

NWS CHPS Modeling Units: 12 CONUS RFCs

Export Data elements from the simulation workflow including:

- INFW – Inflow to the “Channel”
- Mean Areal Precipitation (MAP)
- Reservoir Outflow (QINE)

PI-XML to WaterML2

XMRG to NetCDF

Data Services – local runoff

Experimental distributed model (SAC-HTET)

Slide: Ed Clark, NWS (pre-decisional)
National Flood Interoperability Experiment Data Framework

Geospatial

Hydrology (RFC Basins, NHDPlus Catchments)

Hydraulics (National Flood Hazard Layer, Flood Inundation Map Libraries)

Temporal

Time Series (WaterML2 and .csv)

Multidimensional Arrays (WCS and netCDF)
Iowa Flood Information System
Established after 2008 Iowa Flood

http://www.iowafloodcenter.org
To develop hydrologic models for physically based flood frequency estimation and real-time forecasting of floods, including hydraulic models of flood plain inundation mapping.
High resolution hydrologic modeling
State-wide coverage of high resolution modeling

In NFIE use WRF-Hydro/RAPID to do this for CONUS
Install water level sensors on the back of bridges ($3000 per site)
Iowa has deployed 180 of these sensors
Plans for 70 more

Develop a National Flood Sensor Network
Conclusions

• National Water Center is being established in Tuscaloosa, Alabama

• Offers an opportunity to do things differently in the future than in the past

• National Flood Interoperability Experiment (Sept 2014 to August 2015) to explore how to do this for flooding

• All are welcome to participate

• Possible National Drought Interoperability Experiment in 2015-2016