National Weather Service
Flash Flood Warning Services

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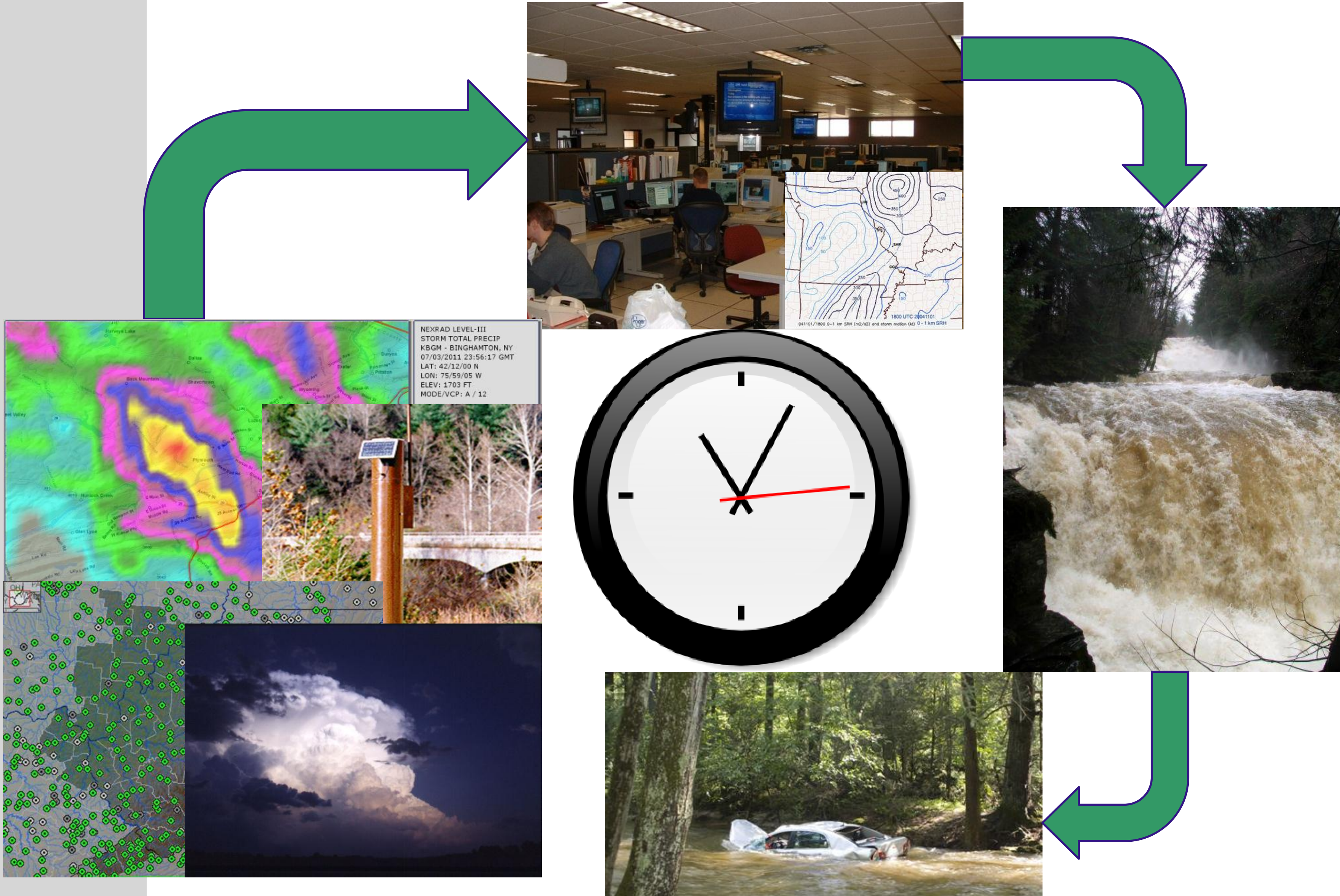
January 24, 2012

Meeting the Nation’s Needs

Building a Weather-Ready Nation

- **The Nation must be prepared to respond to weather impacts**
- **To better prepare the Nation, NOAA must:**
  - *Effectively communicate risk and forecast confidence levels*
  - *Develop more responsive and meaningful products and services to society*
  - *Provide more efficient delivery of products and services in a technologically changing world*

The Flash Flood Problem



Topics

- Computing the Rainfall
- Modeling the Basin Response
- Analyzing the Situation
- Communicating the Warning Message
- Completing Life Saving Actions
- Evolution of Services

Section 1
Computing the Rainfall

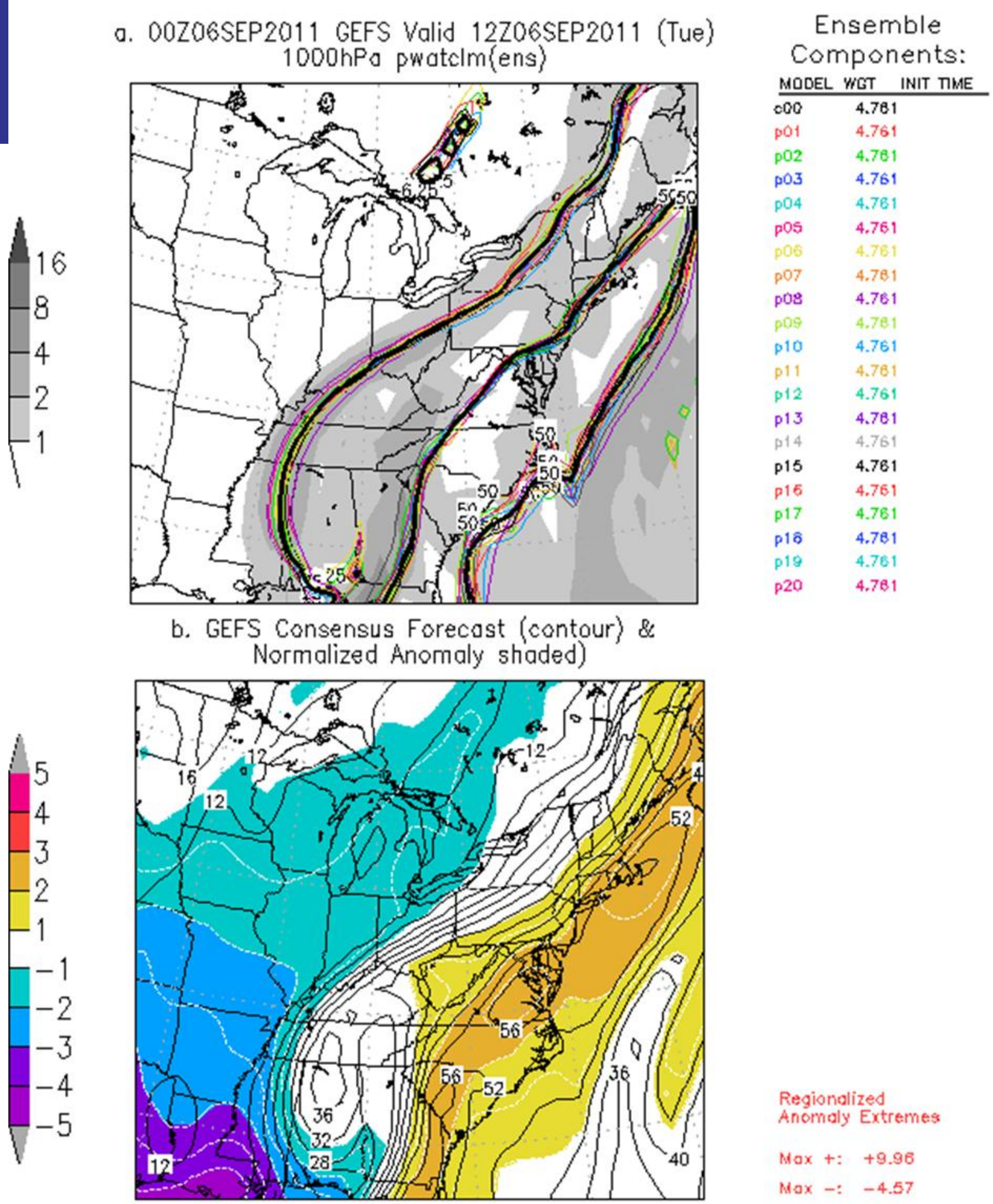
Rainfall Potential

SITUATIONAL AWARENESS:

Look for conditions that often lead to heavy rainfall:

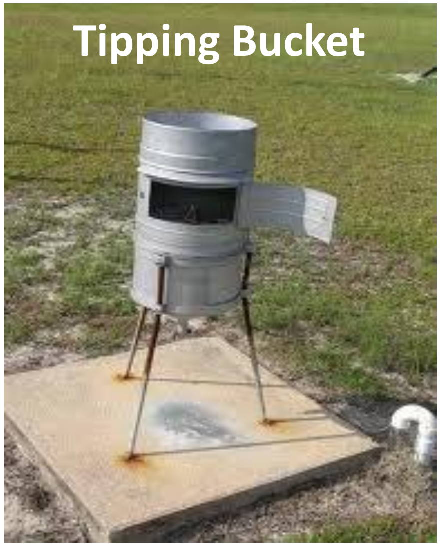
- Anomalously High Precipitable Water
- Anomalously High Moisture Advection
- Near Stationary Frontal Boundary
- Anomalously strong southerly low level jet winds (winds from a warm body of water)
- Right Rear Entrance Region of Upper Jet wind
- Orographic enhancement

- See case studies of the use of anomalies at:
- http://nws.met.psu.edu/



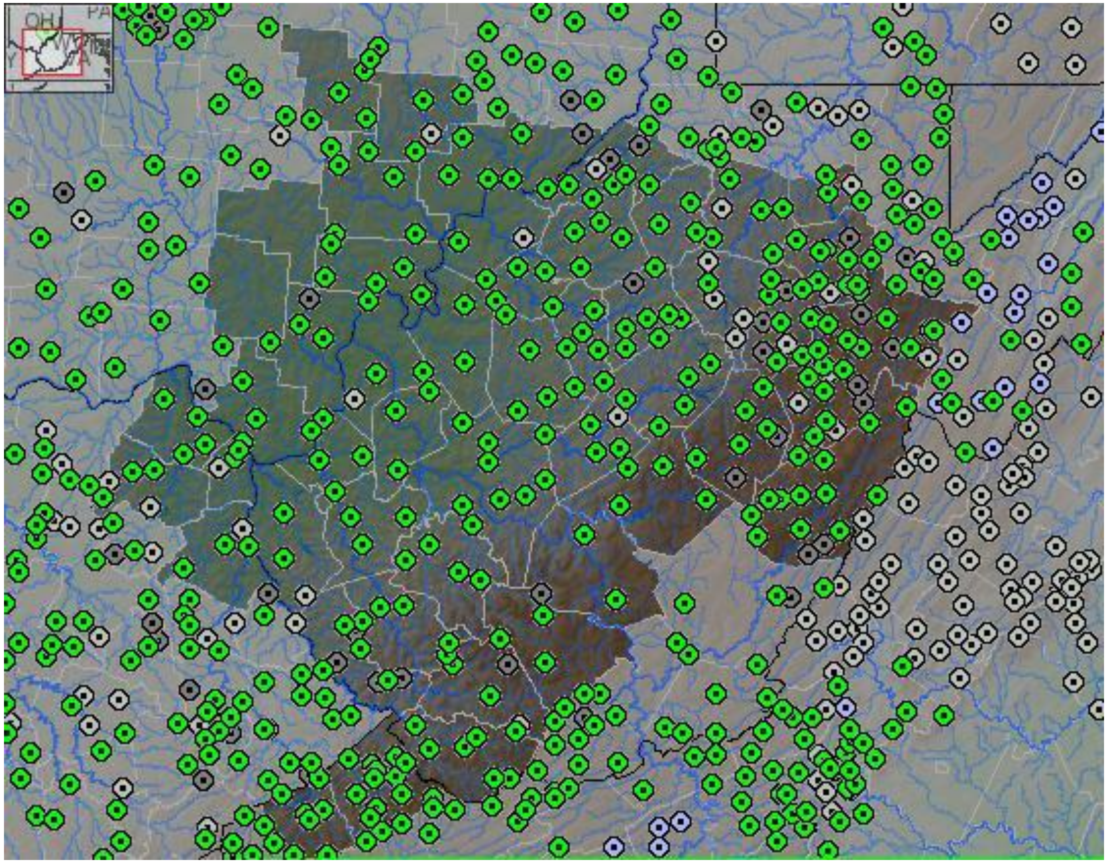
Computing the Rainfall

Sources of data



Integrated Flood Observing and Warning System (IFLOWS)

1,700 gages in 12 States
Gage readings updated every 5 minutes

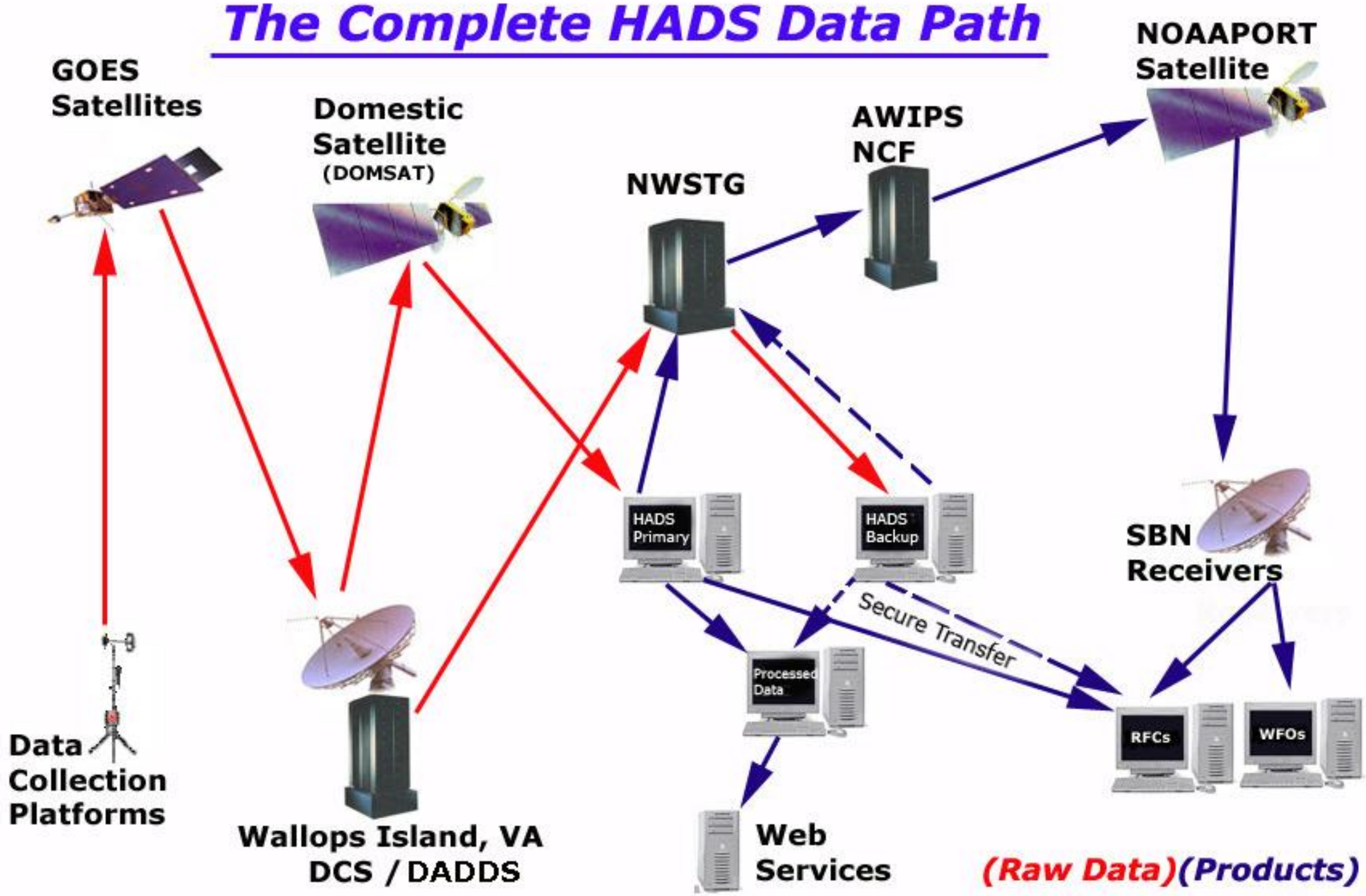


http://afws.erh.noaa.gov/afws/national.php

HADS

Hydrometeorological Automated Data System

The Complete HADS Data Path

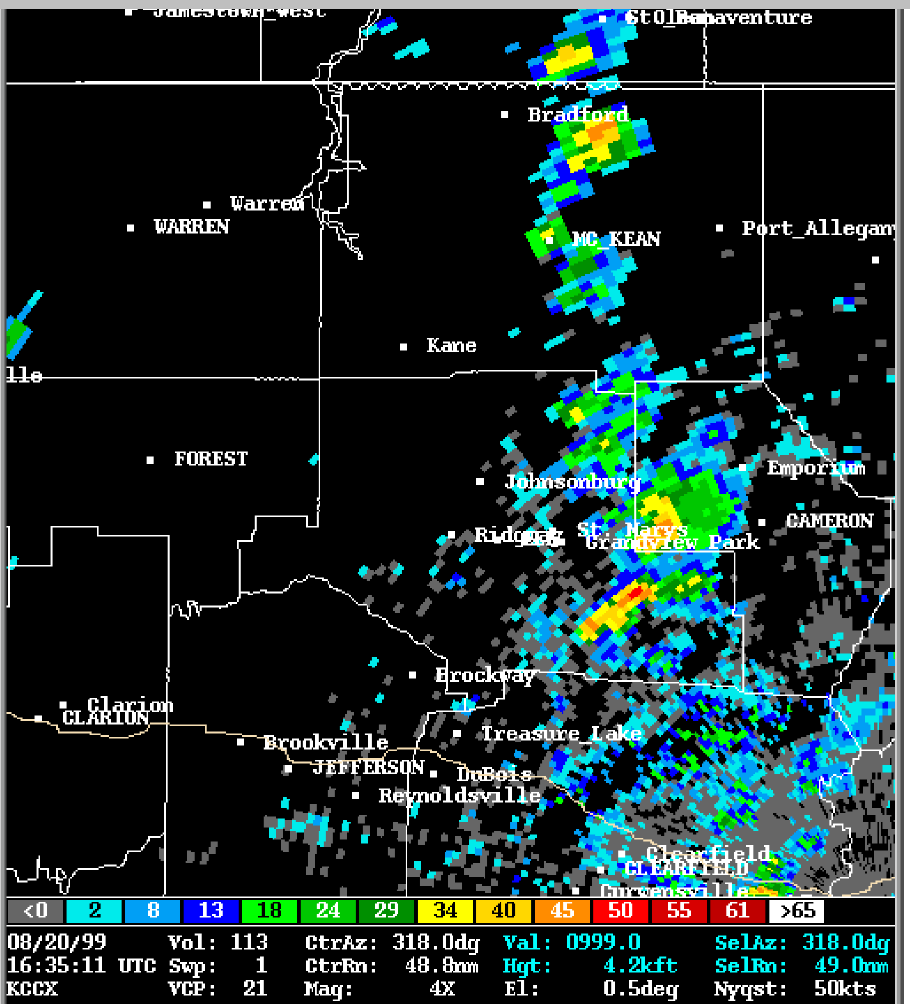


HADS Cooperators

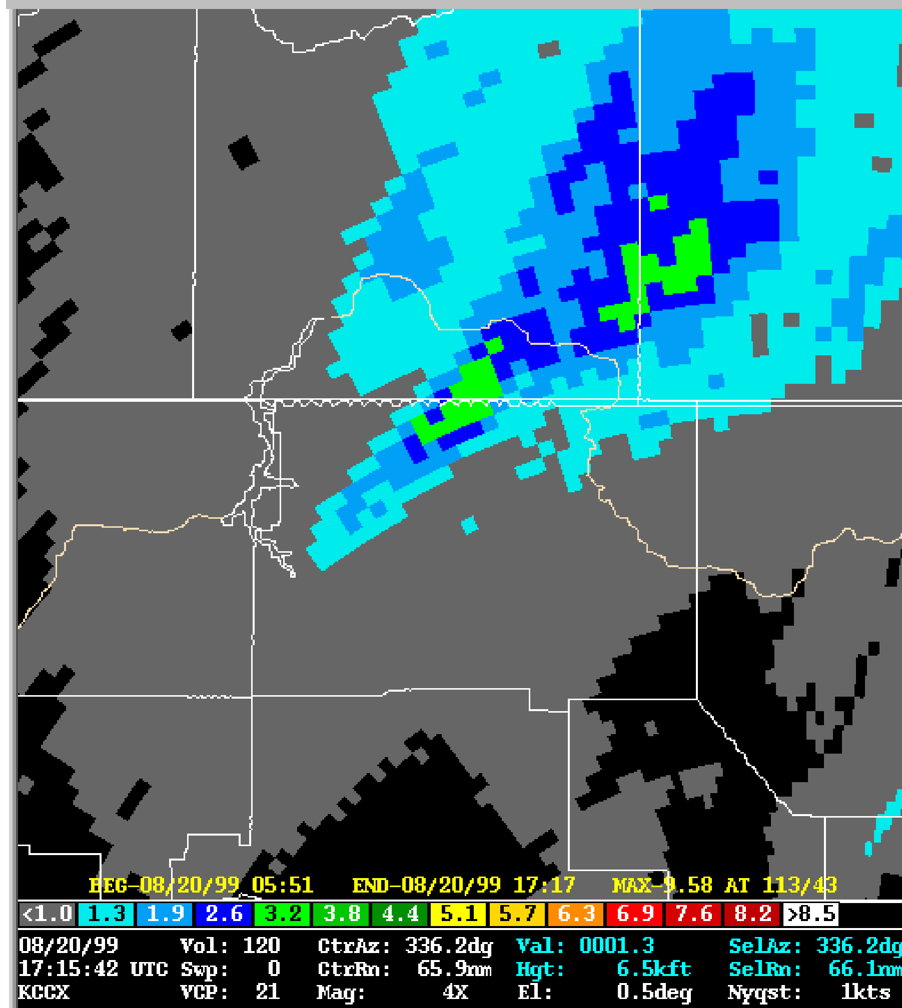
Example of radar rainfall estimates…

Radar estimated over 9.7” (246mm)…Bradford Fire Dept measured 8.9” (226mm).

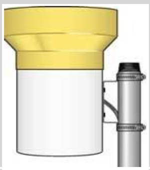
Loop of Radar Reflectivity



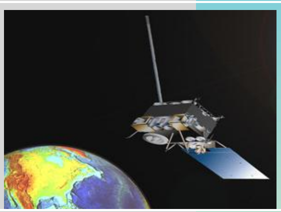
Loop of Rainfall Estimates



Hourly Quantitative Precipitation Estimate (QPE)

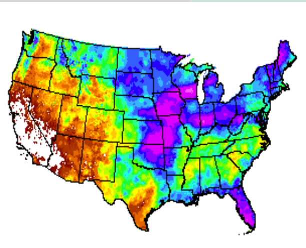


Quality-Controlled Precipitation Gage Measurement



GOES Satellite Estimate

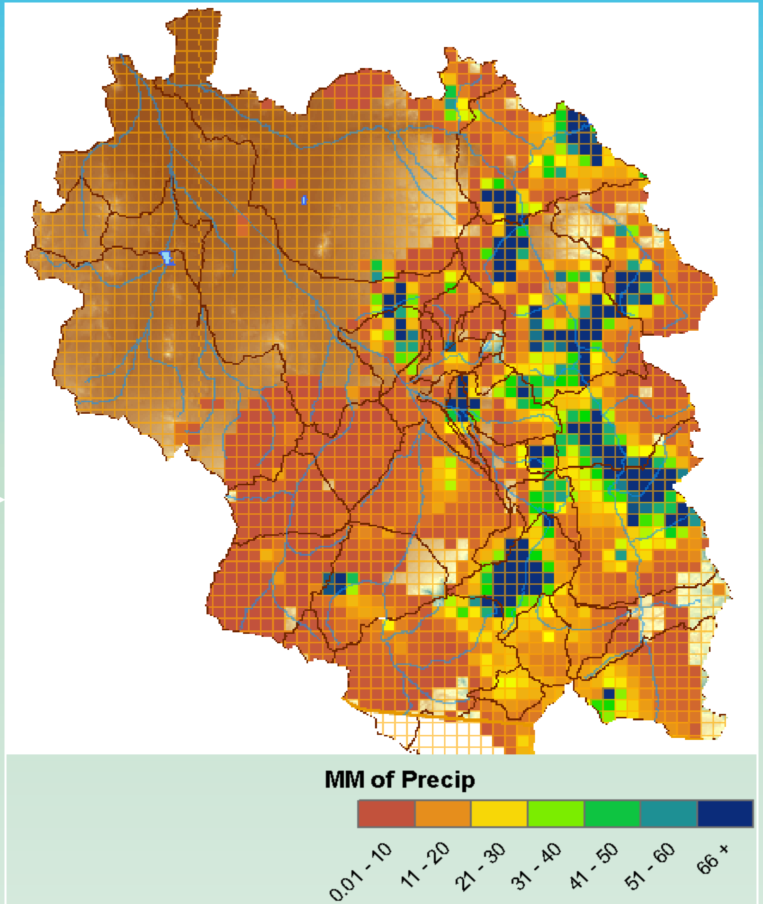
Radar Estimate



Climate patterns

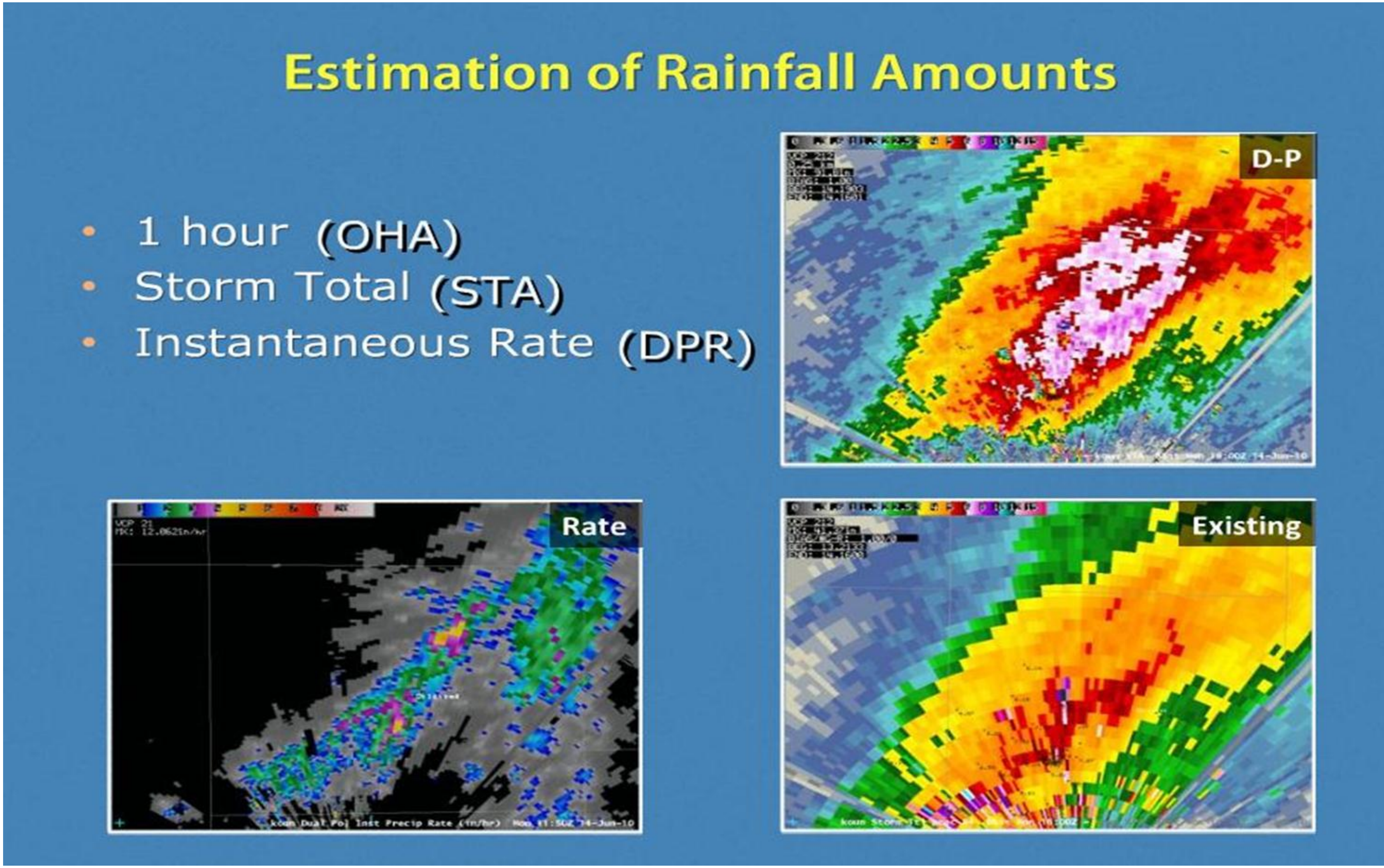
MPE Software

Forecaster Analysis

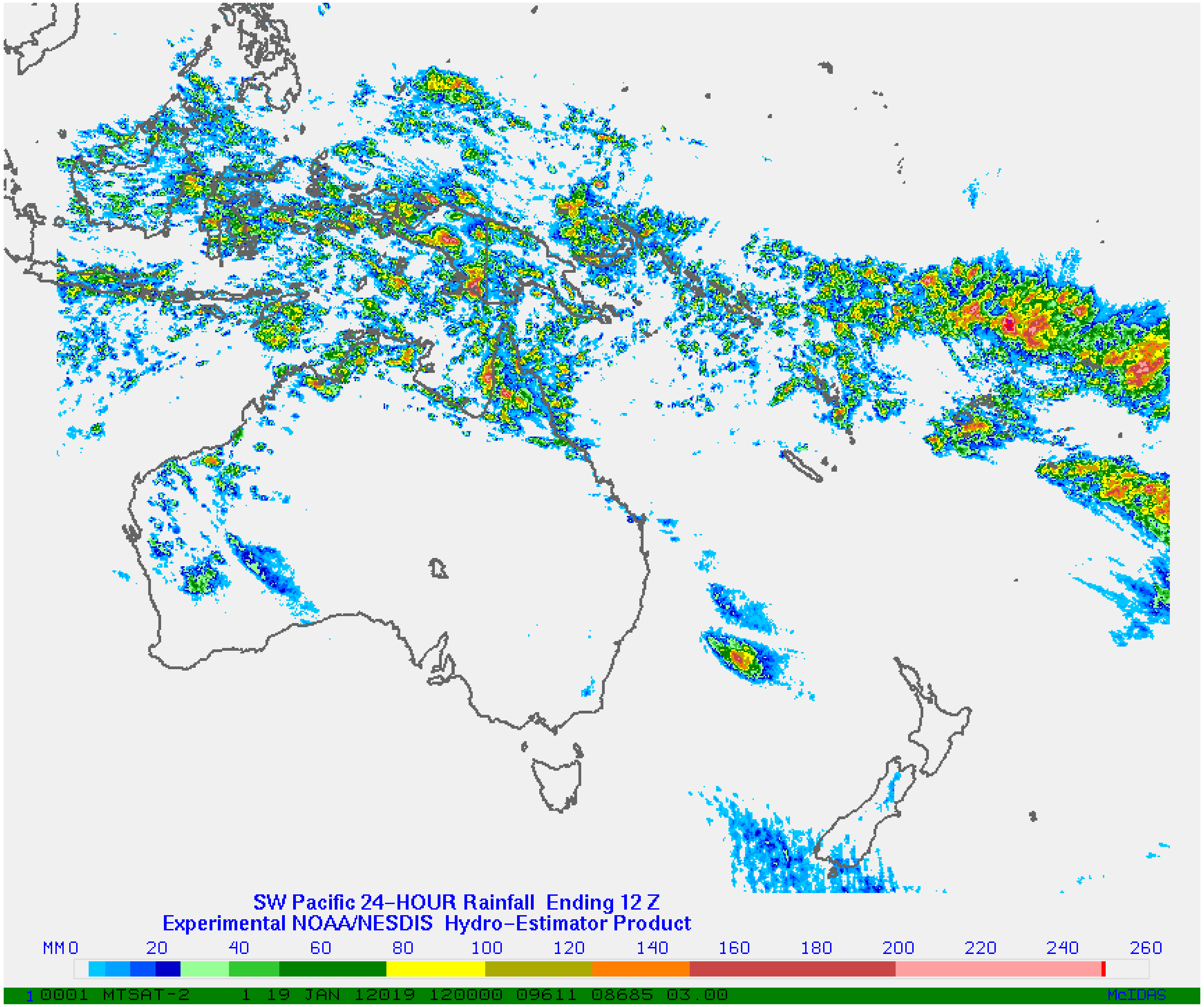


Gridded Precipitation Estimate

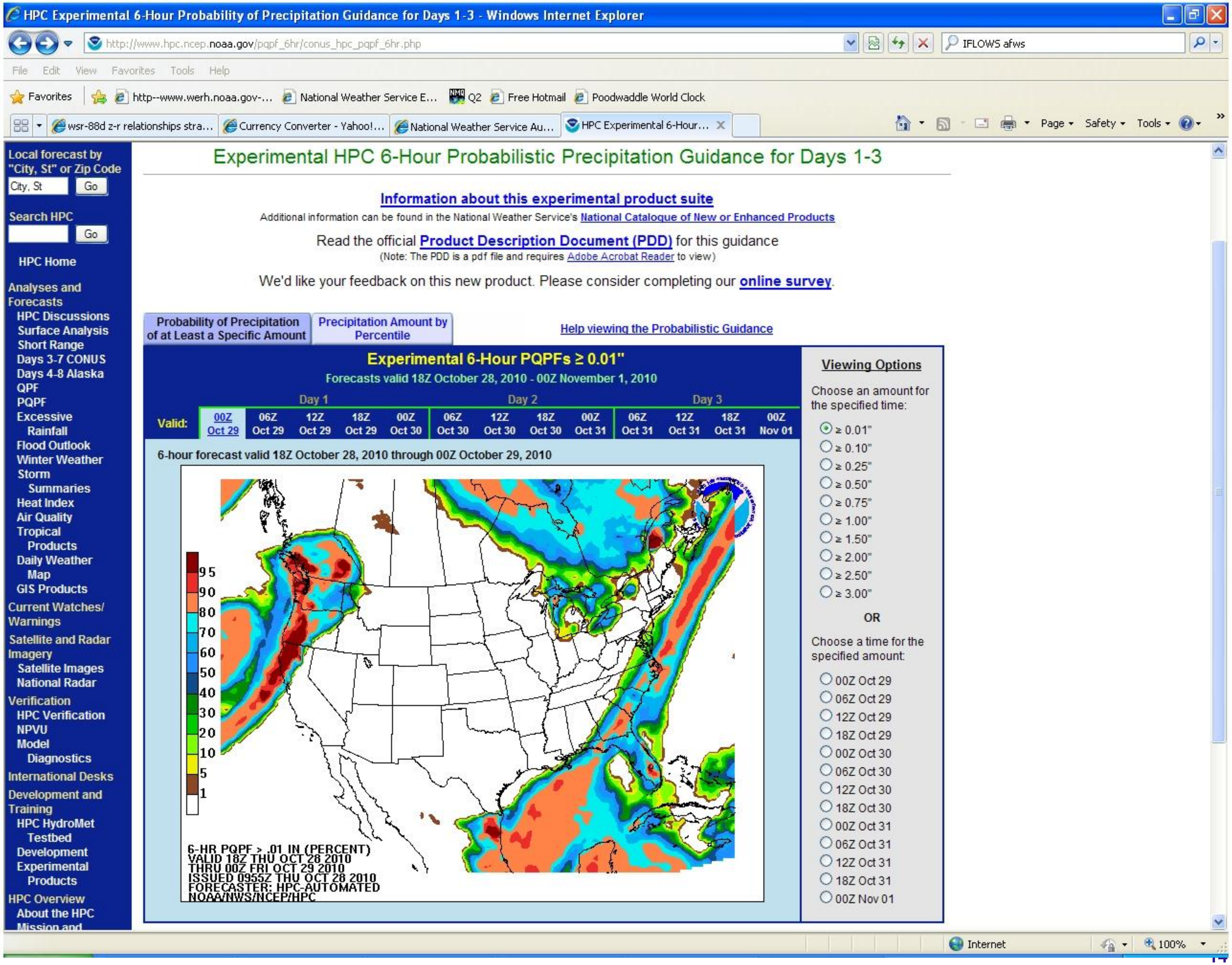
Dual Pole Radar Technology will improve rainfall estimates and identify different types of precipitation.



NESDIS Hydroestimator – satellite based rainfall

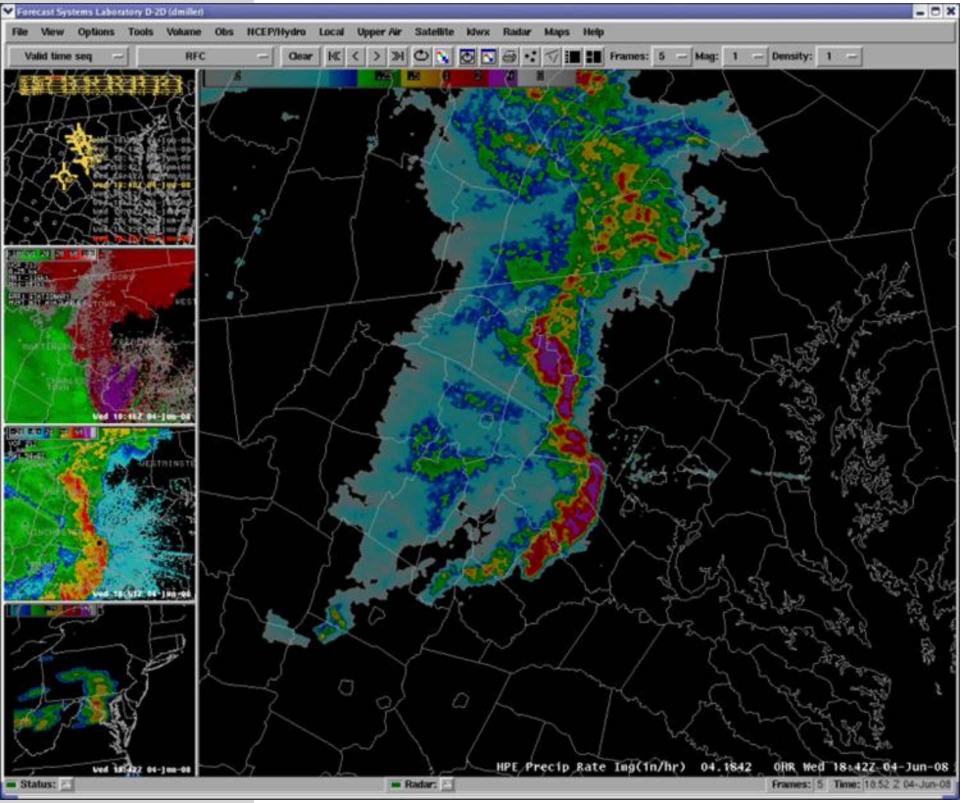


Short Term Rainfall Forecasts

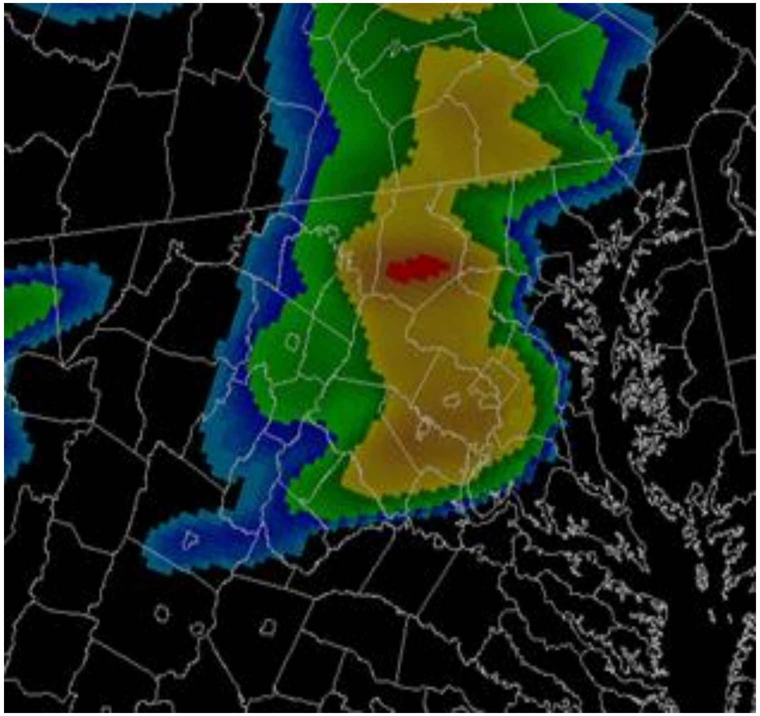


Short Term Rainfall Forecasts

High-resolution Precipitation Nowcaster (HPN)



Rainfall Rate, 1842Z 6/4/2008



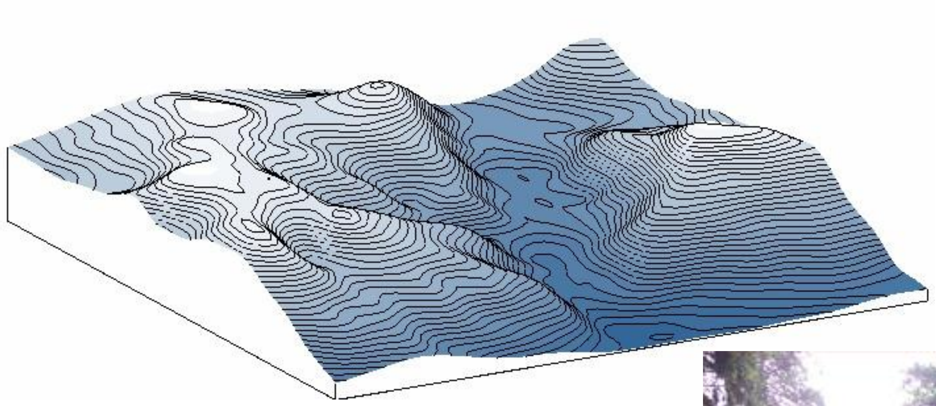
1-hour Rainall Nowcast, valid at 1942Z 6/4/2008

Section 2

Modeling the Basin Response

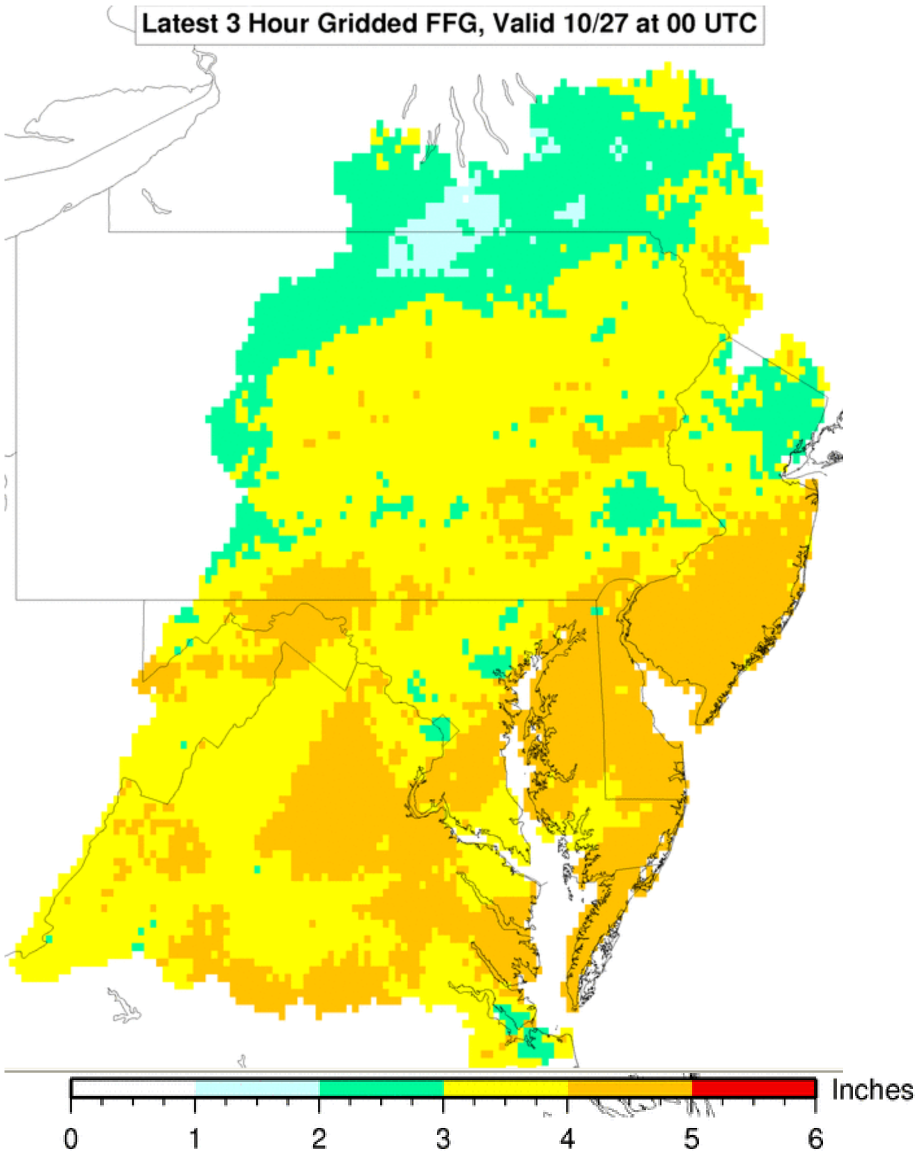
How much rain is needed for Flash Flooding?

- Rainfall needed dependent on:
  - Antecedent conditions
  - Basin characteristics



Flash Flood Guidance

- Issued by RFCs
- Updated 1-4 times daily



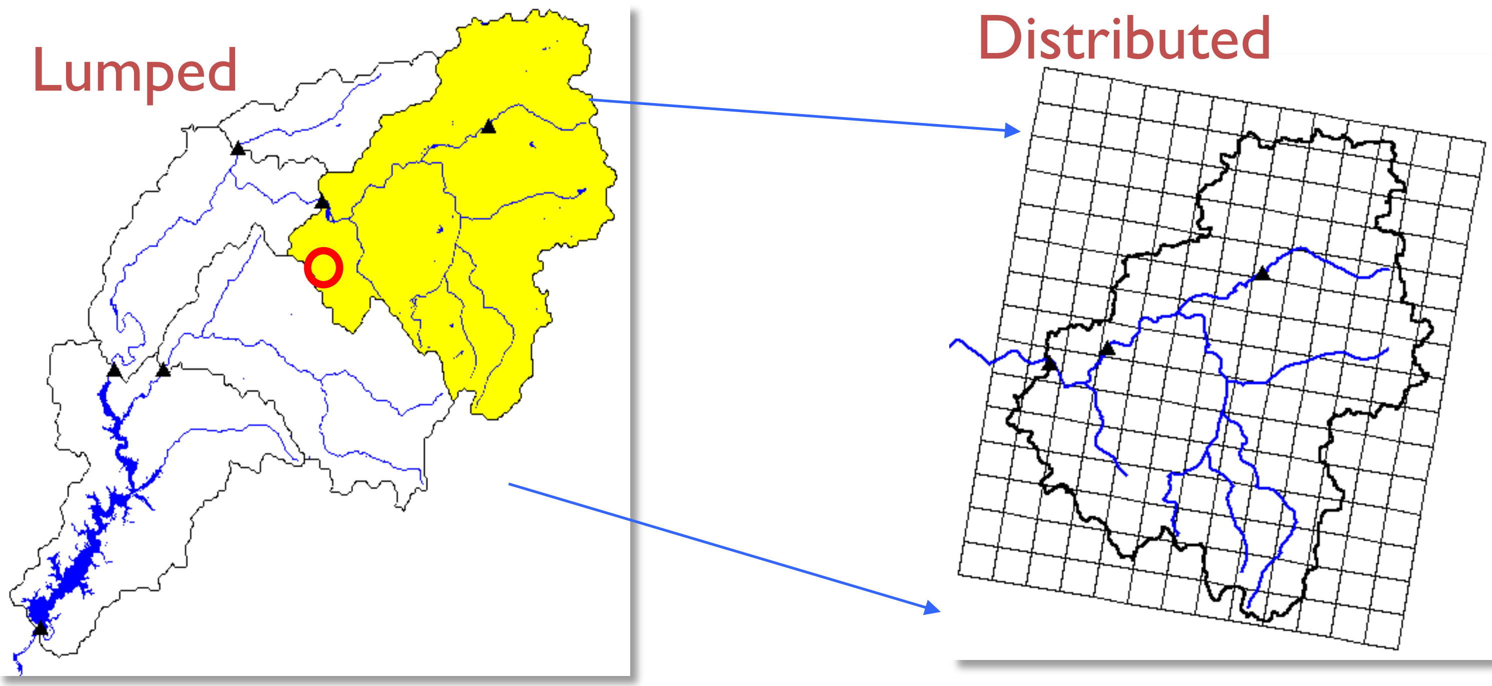
Headwater Guidance

- Issued by RFCs
- Updated 1-4 times daily

```
:IDENT    1HR   3HR   6HR  12HR  HEADWATER NAME        STREAM
:======= ==== ==== ==== ==== ==================== ==============
:
: NWS BROOKHAVEN SERVICE AREA...
:  Ramapo River...
MAHN4     4.5/  5.0/  5.3/  5.5 :Mahwah (8ft.)         Ramapo River
:MAHN4md  5.8/  6.5/  6.9/  7.1 :Mahwah (9)            Ramapo River
:MAHN4mj  6.5/  7.0/  7.4/  8.0 :Mahwah (12)           Ramapo River
:  Hohokus Brook...
HOHN4     1.8/  2.0/  2.6/  3.7 :Ho-Ho-Kus (3ft.)      Hohokus Brook
:  Saddle River...
LODN4     2.1/  2.4/  3.2/  3.4 :Lodi (6ft.)           Saddle River
:LODN4md  2.4/  2.8/  3.6/  3.8 :Lodi (7)              Saddle River
:LODN4mj  2.8/  3.2/  4.2/  4.4 :Lodi (8)              Saddle River
:  Rahway River...
SPGN4     2.4/  2.5/  2.7/  3.3 :Springfield (5.5ft)   Rahway River
```

Lumped Versus Distributed Models

★ Distributed models are well-suited for flash flood prediction and monitoring, offering high-resolution streamflow at outlet and interior points with ability to route flow



Lumped

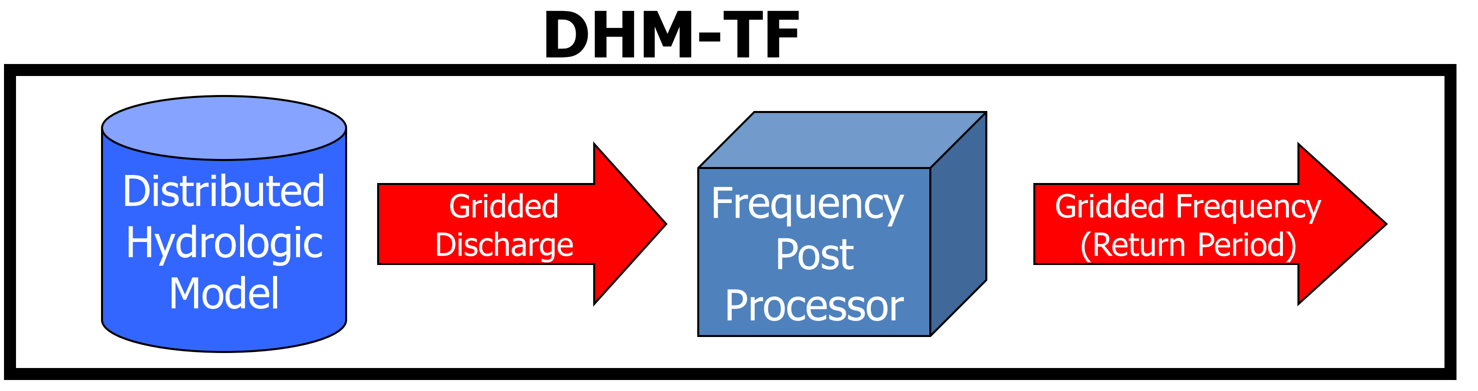
1. Rainfall and soil properties averaged over basin
2. Single rainfall/runoff model computation for entire basin or sub-basin
3. Prediction/verification <u>only</u> at outlet point

Distributed

1. Rainfall, soil properties vary by grid cell
2. Rainfall/runoff model applied separately to each grid cell
3. Prediction/verification at <u>any</u> grid cell

DHM-TF: An application of distributed modeling

- What is DHM-TF?
  - A generic **statistical post-processing** of Distributed Hydrologic Model Output.
  - Provides way to cast flood severity in terms of **return period** by converting model flow forecasts to frequency

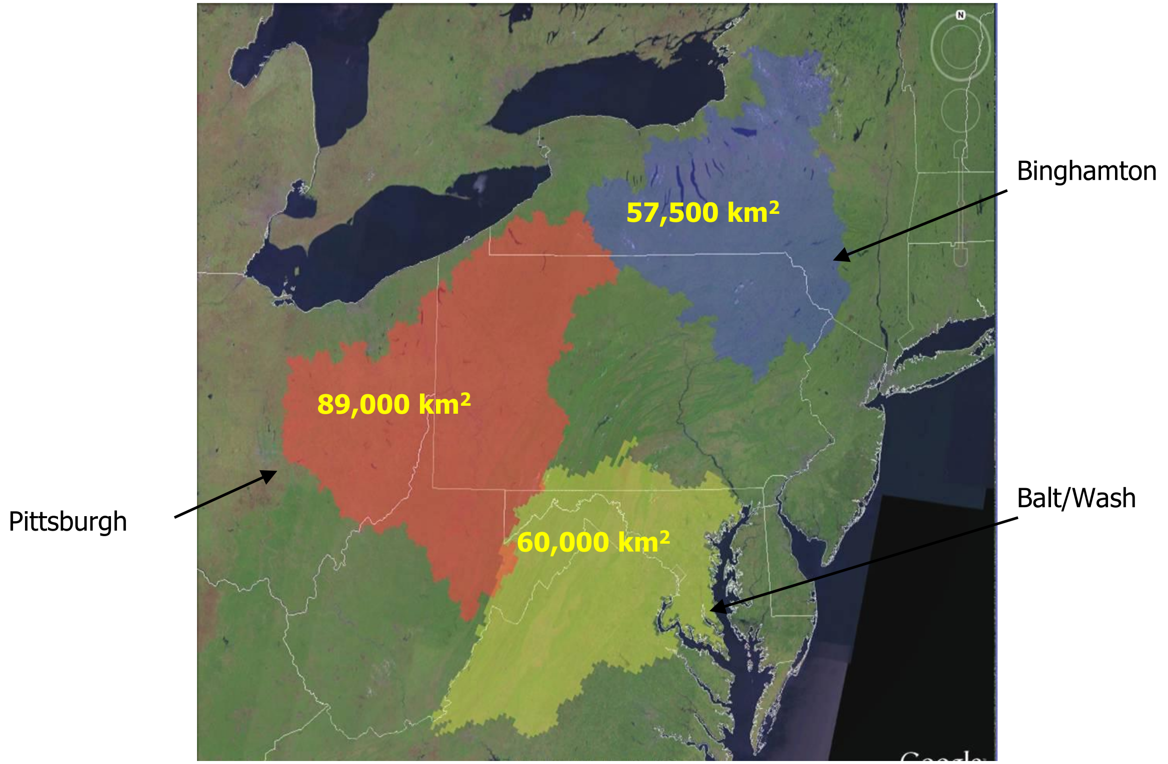


  - Communicate the **impact of the response** without the flow/stage relationship that can be developed at a stream gage.
  - Make the current grid states **meaningful to the forecaster**.

Current DHM-TF Pilot Implementations

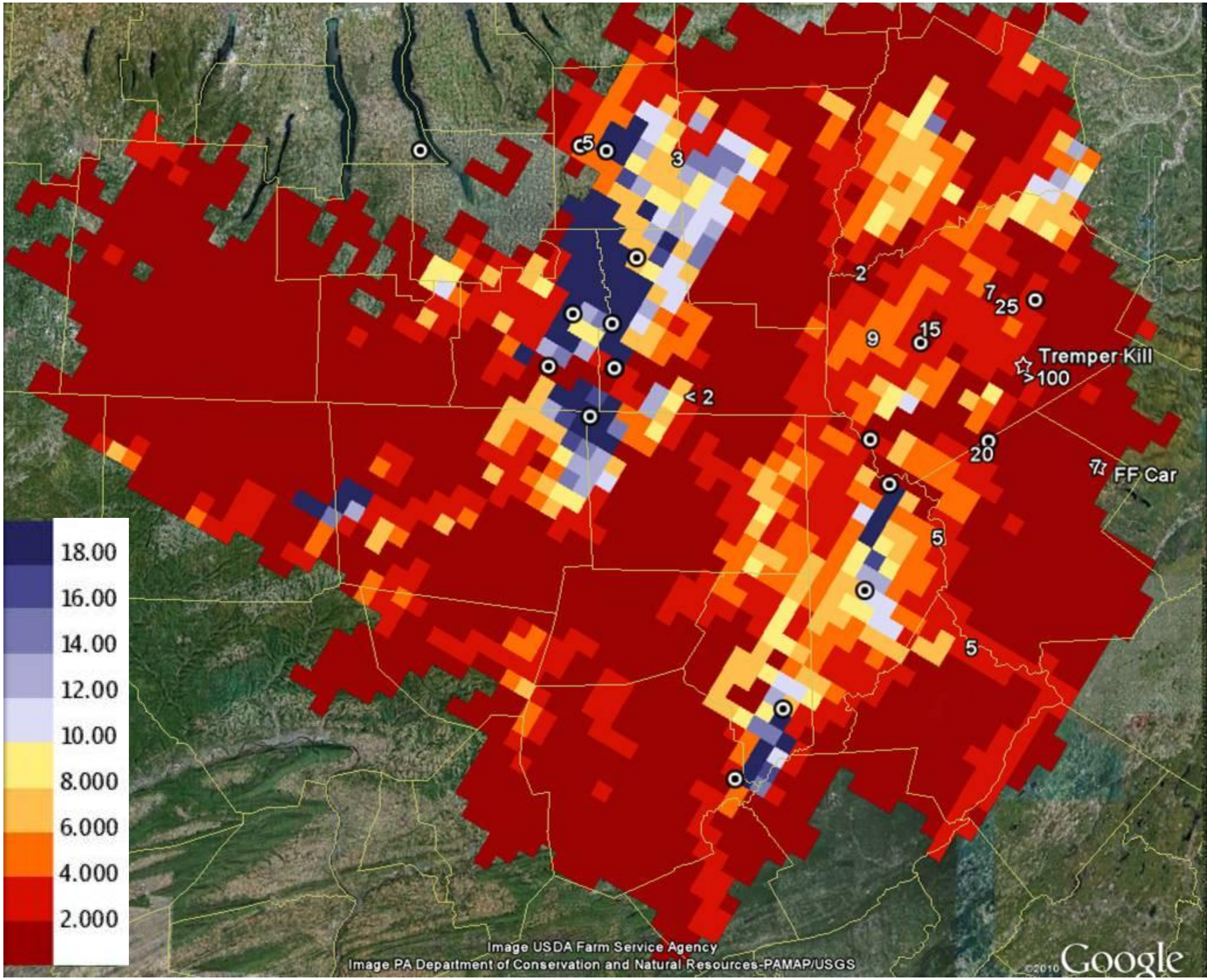
- DHM-TF pilot studies are underway in coordination with NWS Weather Forecast Offices (WFOs) and River Forecast Centers (RFCs)
  - Binghamton and Pittsburgh WFO domains on WFO servers
  - Baltimore/Washington WFO domain on OHD server (transitioning to WFO)

Pittsburgh, Binghamton, and Balt/Wash WFO Domains



Verification: Binghamton WFO, October 1st, 2010 Flood Event

DHM-TF Maximum Return Period (Analysis w/Routing) 12Z 9/30/10 to 00Z 10/03/10



Return Period Spatial Analysis

- Excellent spatial agreement between areas of 2+ year return periods and local storm reports
- Isolated areas with > 100 year return periods

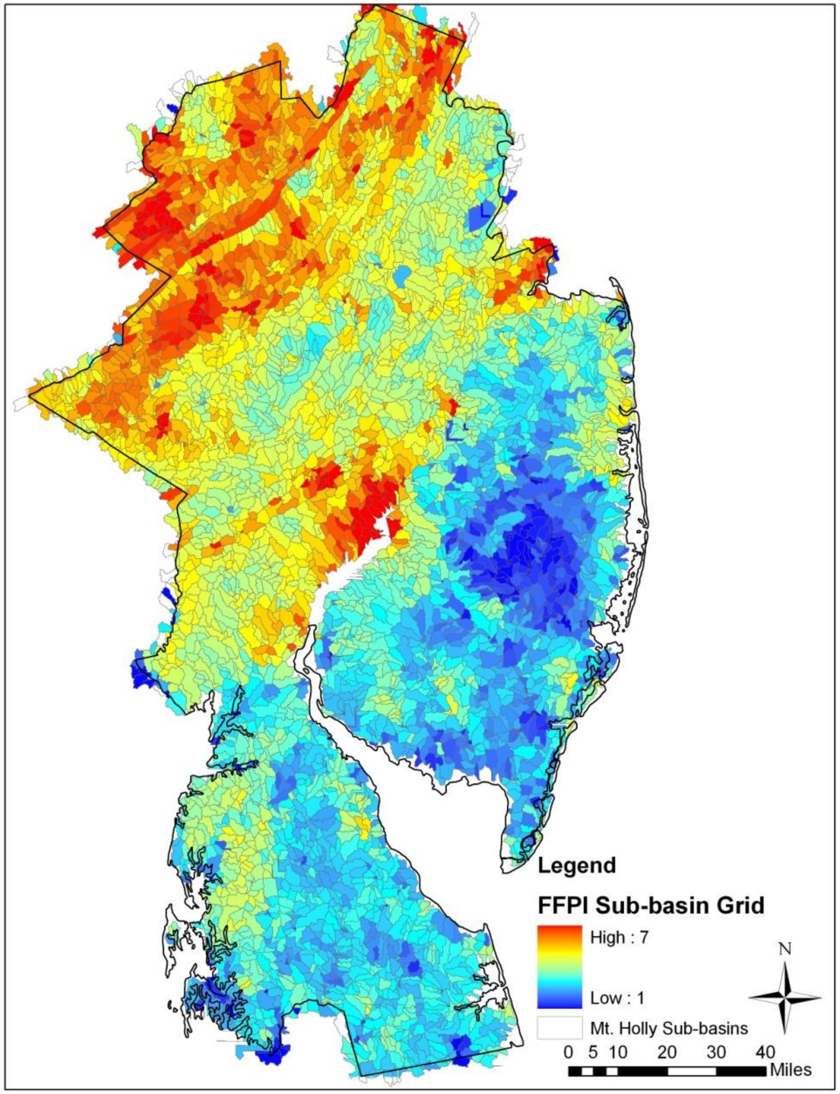
#'s = USGS Gauge Return Period

◉ = Local Storm Reports

☆ = NWS Storm Reports

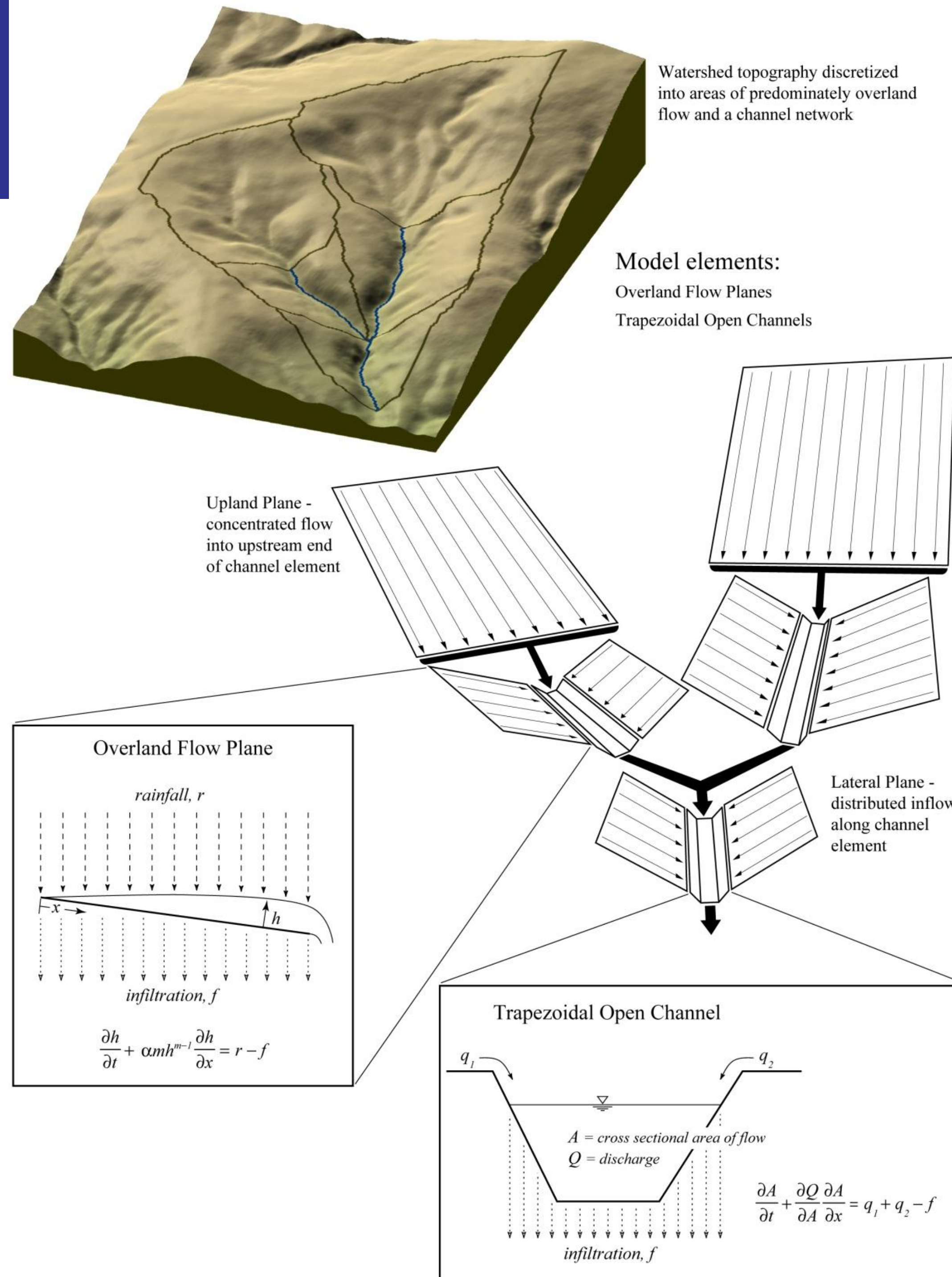
Flash Flood Potential Index

- Maps relative threat of flash flooding based on:
  - Slope
  - Land usage
  - Soil type
  - Vegetation
- Does not change because it does not take recent rainfall, soil moisture into account

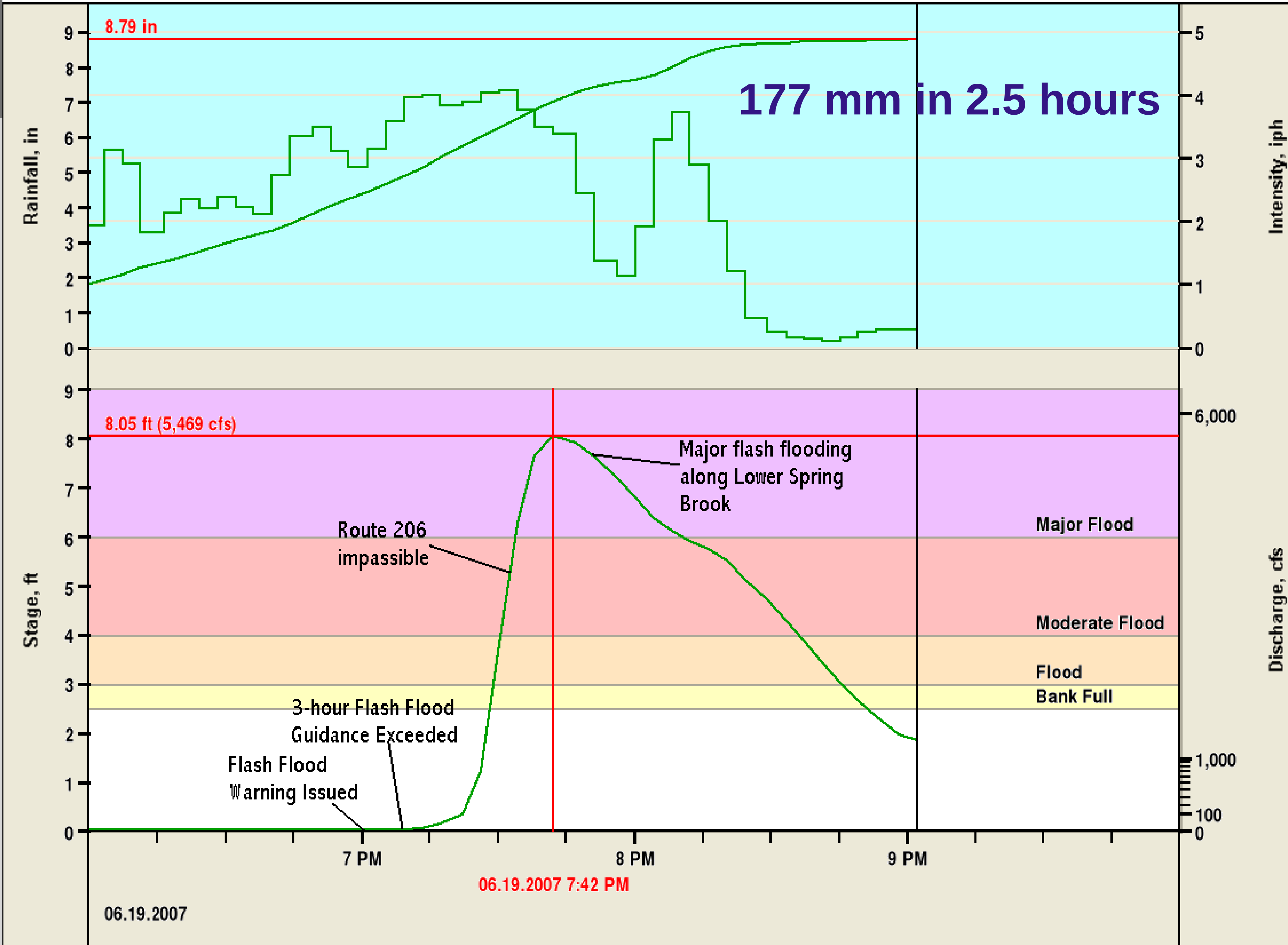


KINEROS

- Simulates runoff response in basins having predominantly overland flow.

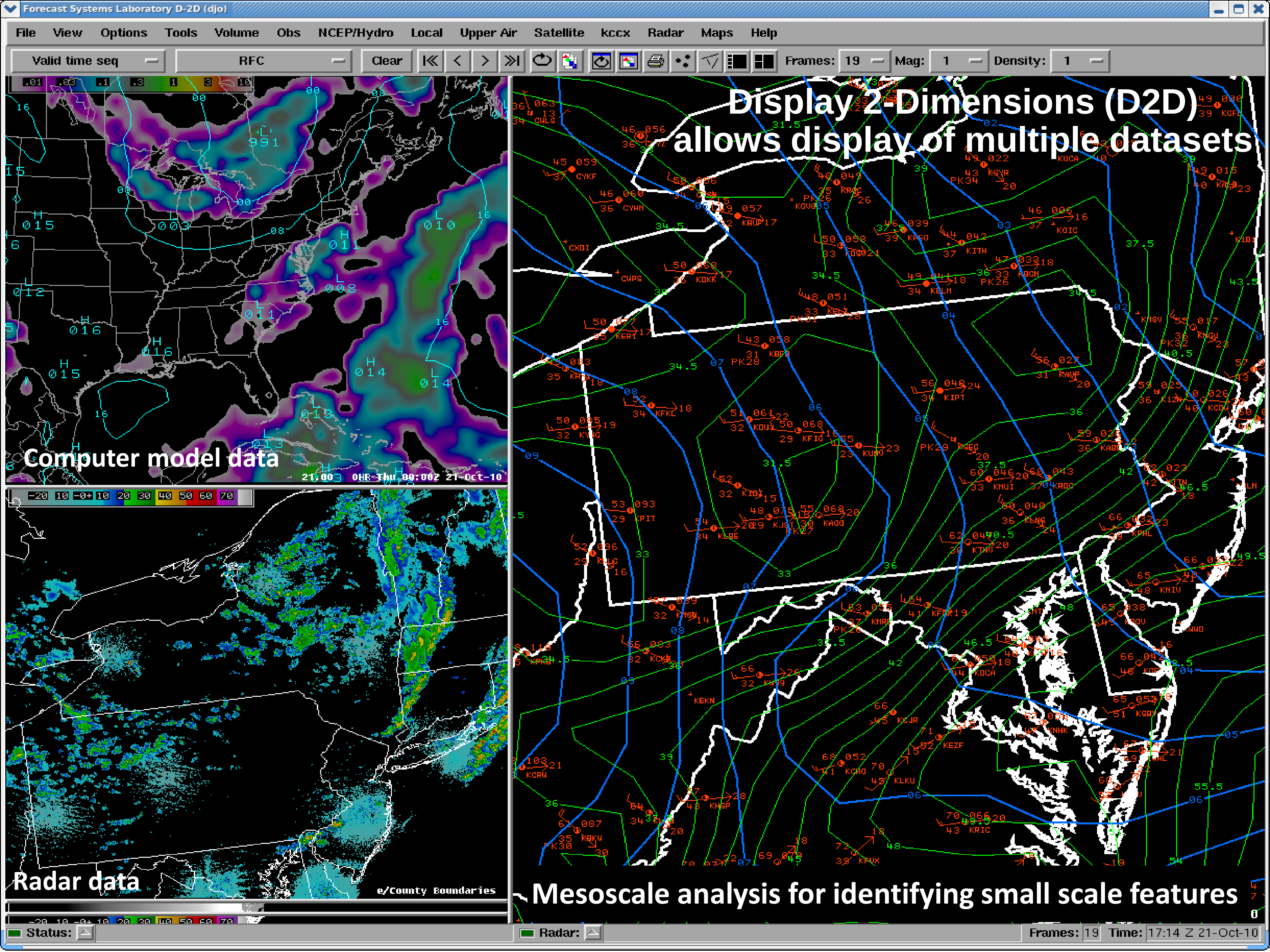


Spring Brook north of Roscoe along Route 206 - KINEROS Site Specific Forecast Model

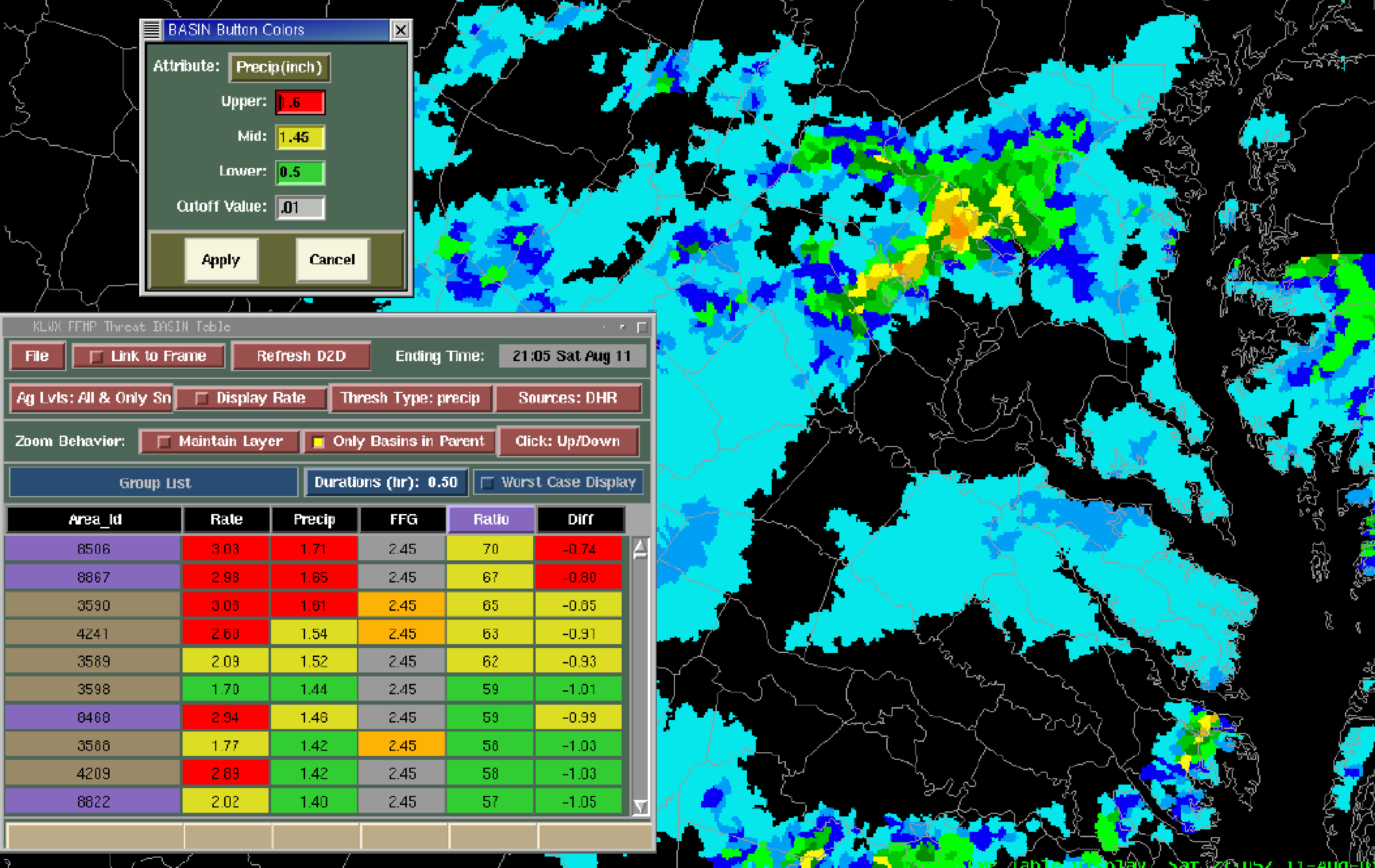


Section 3

Analyzing the Threat


Forecast Systems Laboratory D-2D (djo)
File View Options Tools Volume Obs NCEP/Hydro Local Upper Air Satellite kccx Radar Maps Help
Valid time seq
RFC
Clear
Frames: 19
Mag: 1
Density: 1
Display 2-Dimensions (D2D) allows display of multiple datasets
Computer model data
Radar data
Mesoscale analysis for identifying small scale features
Status:
Radar:
Time: 17:14 Z 21-Oct-10

Flash Flood Monitoring and Prediction (FFMP) software allows Forecasters to see current radar derived rainfall rates, rainfall totals, and compares data to Flash Flood Guidance. This software helps forecasters identify areas of possible flooding sooner.



Area_Id	Rate	Precip	FFG	Ratio	Diff
8506	3.03	1.71	2.45	70	-0.74
8867	2.98	1.65	2.45	67	-0.80
3590	3.06	1.61	2.45	65	-0.85
4241	2.60	1.54	2.45	63	-0.91
3589	2.09	1.52	2.45	62	-0.93
3598	1.70	1.44	2.45	59	-1.01
8468	2.94	1.46	2.45	59	-0.99
3588	1.77	1.42	2.45	58	-1.03
4209	2.89	1.42	2.45	58	-1.03
8822	2.02	1.40	2.45	57	-1.05

The use of FFMP has improved the quality and timeliness of warnings.

- **A study conducted in 2010 compared national verification statistics**
  - Study looked at data from 1997-2000 (pre-FFMP) to those from 2006-2009 (post FFMP installation).

Years of Study	Probability of Detection (POD)	% of warnings with > 0 min lead time	Average lead time for warnings	False Alarm Ratio (FAR)
1997-2000	0.85	66%	47 min	0.42
2006-2009	0.91	79%	64 min	0.56

Green numbers show improvement between datasets. Note: the increase in FAR during the post FFMP installation is likely due to the issuance of warnings in remote location prior to flooding reports being relayed to NWS staff. It is possible that the FAR for 2006-2009 is higher as flooding could have occurred in remote areas and no verification was relayed to NWS personnel.

Real-Time Feedback

- Forecasters need real-time reports of flash flooding and its impacts.
- Acquiring this information is difficult.
- Without ground-truth information
  - forecasters are unsure if flooding events are occurring or not,
  - increased forecaster uncertainty and stress.

David Vann, The Sentinel-Record, Hot Springs, AR

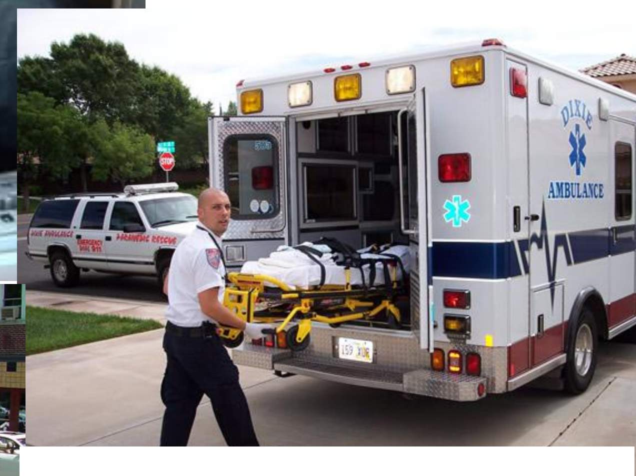
Real-time Feedback

- How to Improve?
  - Volunteer Weather Spotters (SKYWARN)
  - Social Media networks (e.g. Twitter and Facebook)
  - Chat rooms for Forecasters, Emergency Managers and the Media
  - Situational awareness displays

Section 4

Communicating the Warning Message

NO BENEFIT unless the end user gets the warning in time and understands it so they can act

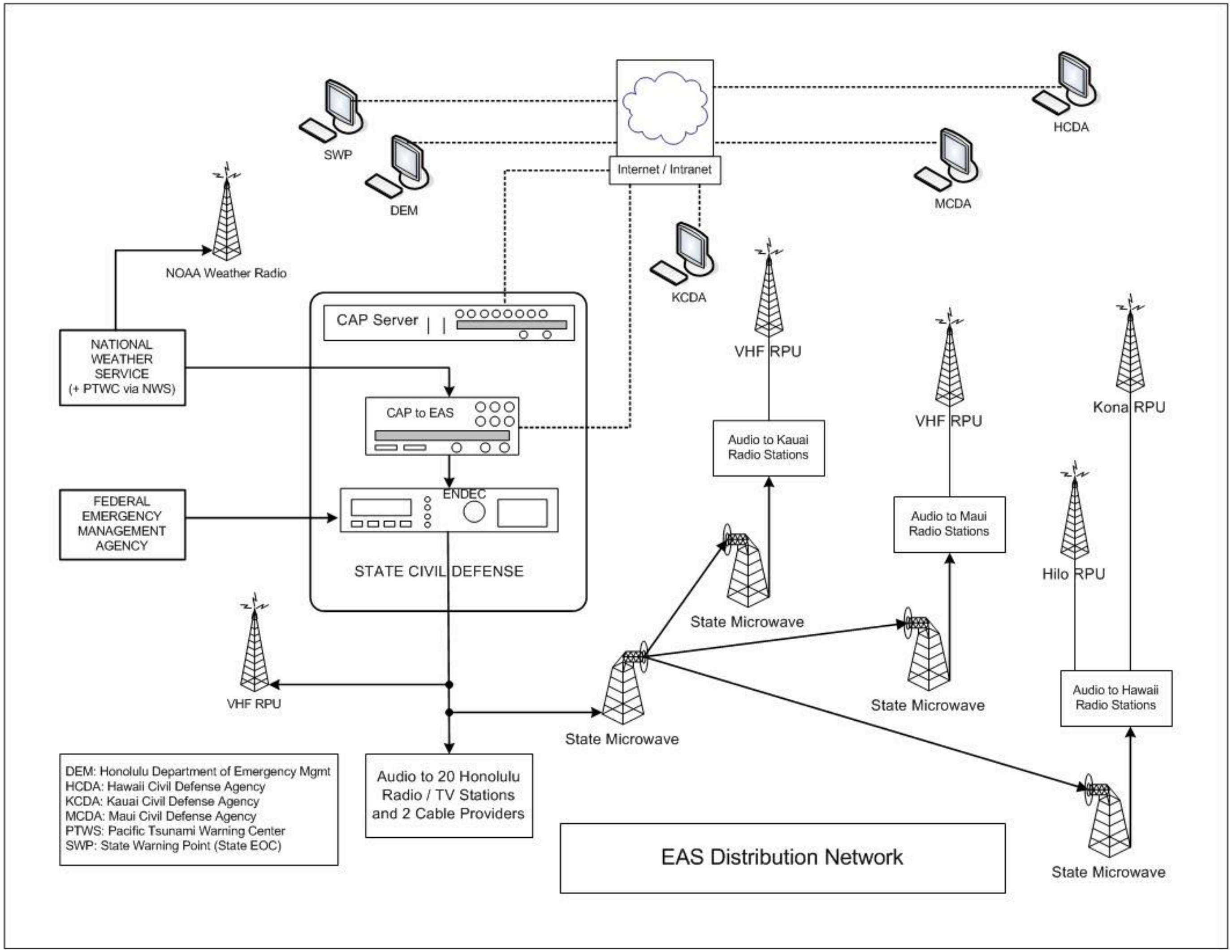


Traditional Dissemination Services

NOAA Weather Radio (NWR)

Emergency Managers Weather Information Network (EMWIN)

Emergency Alert System (EAS)



Integrated Public Alert and Warning System (IPAWS)

IPAWS Architecture

Standards Based Alert Message protocols, authenticated alert message senders, shared, trusted access & distribution networks, alerts delivered to more public interface devices

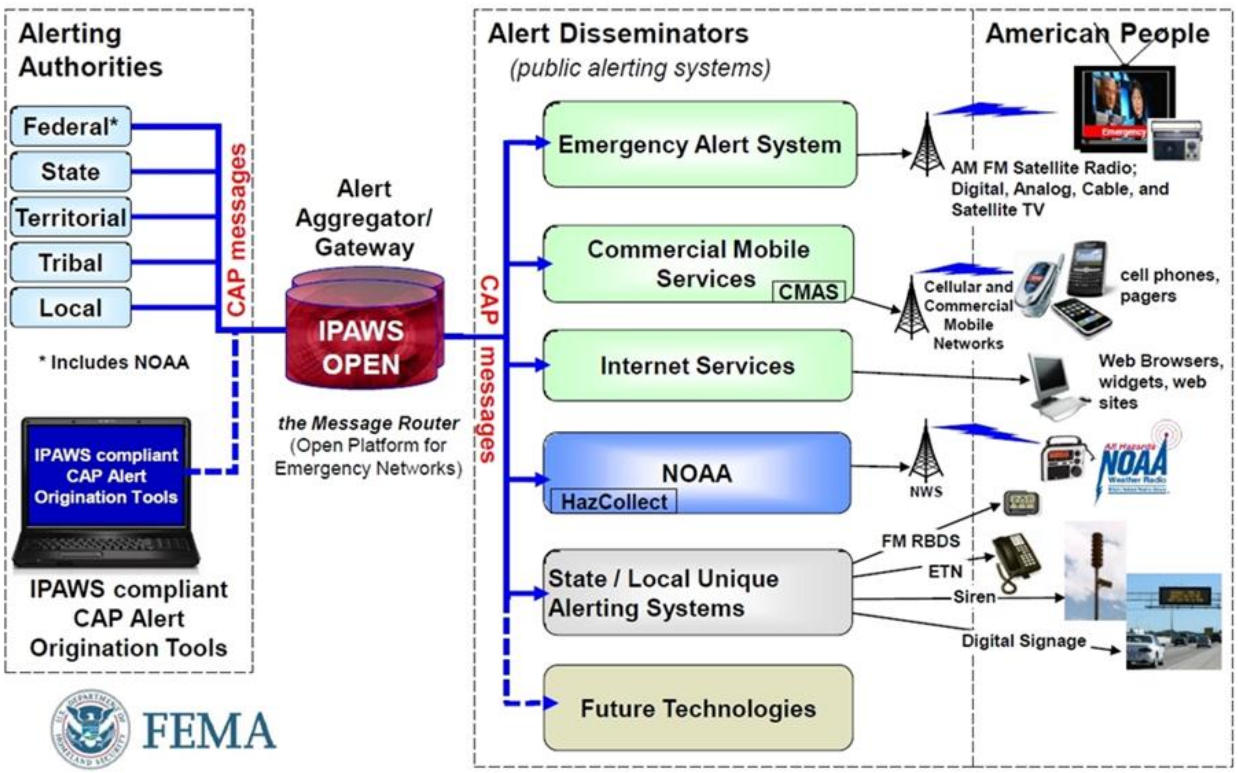


Fig. 6. IPAWS Architecture showing three key components: 1) alert origination by government alerting authorities, 2) alert aggregator/gateway or message router operated by FEMA and, 3) the public alerting systems operated by government agencies and private sector organizations disseminating alerts and warnings to the American people.

[redacted]

For NWS Partners and Emergency Responders

iNWS MOBILE ALERTING

Receive customized text message and e-mail alerts for National Weather Service products that you care about.

Commercial Dissemination Services

- Commercial Services

Weather Alerts & Inbox Weather®

The Weather Channel
weather.com

Weather Underground®
wunderground.com®

U.S. Severe Weather Map
Updated: 12:15 PM GMT on October 22, 2010 — Edit My Time Zone

wtov9.com

SEVERE WEATHER ALERT
CLICK your county for more information

AnythingWeather.com
Your Custom Weather Solution

Severe Weather Alerts

Section 5

Completing Life Saving Actions

Response Factors

- Past Experience
- Understanding and assessment of threat
- Evaluation and Trust in source of information

Response Factors

- What are neighbors doing?

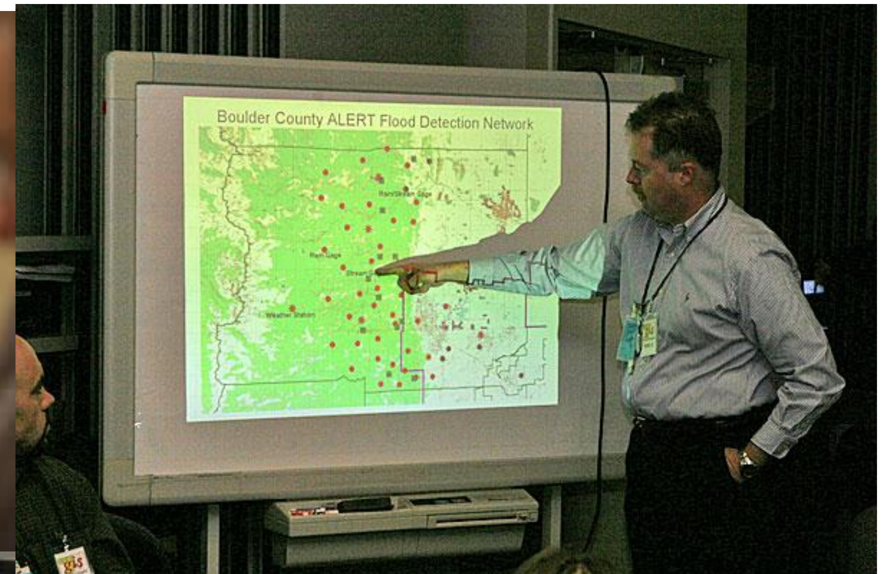
- What are local police/fire departments saying?

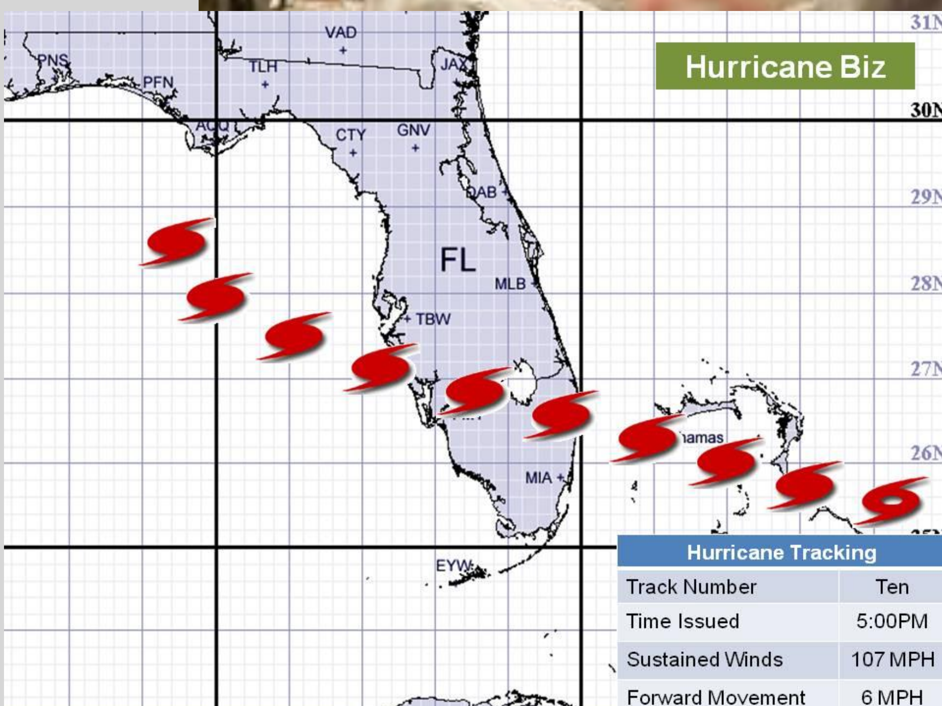
Response Factors

- What are other motorists doing?

- Exposure to Flood Safety Education

“Tabletop” Flood Exercise





Flood Safety Education – Best Practices

Check for the latest forecast

http://www.weather.gov/floodsafety/index.shtml

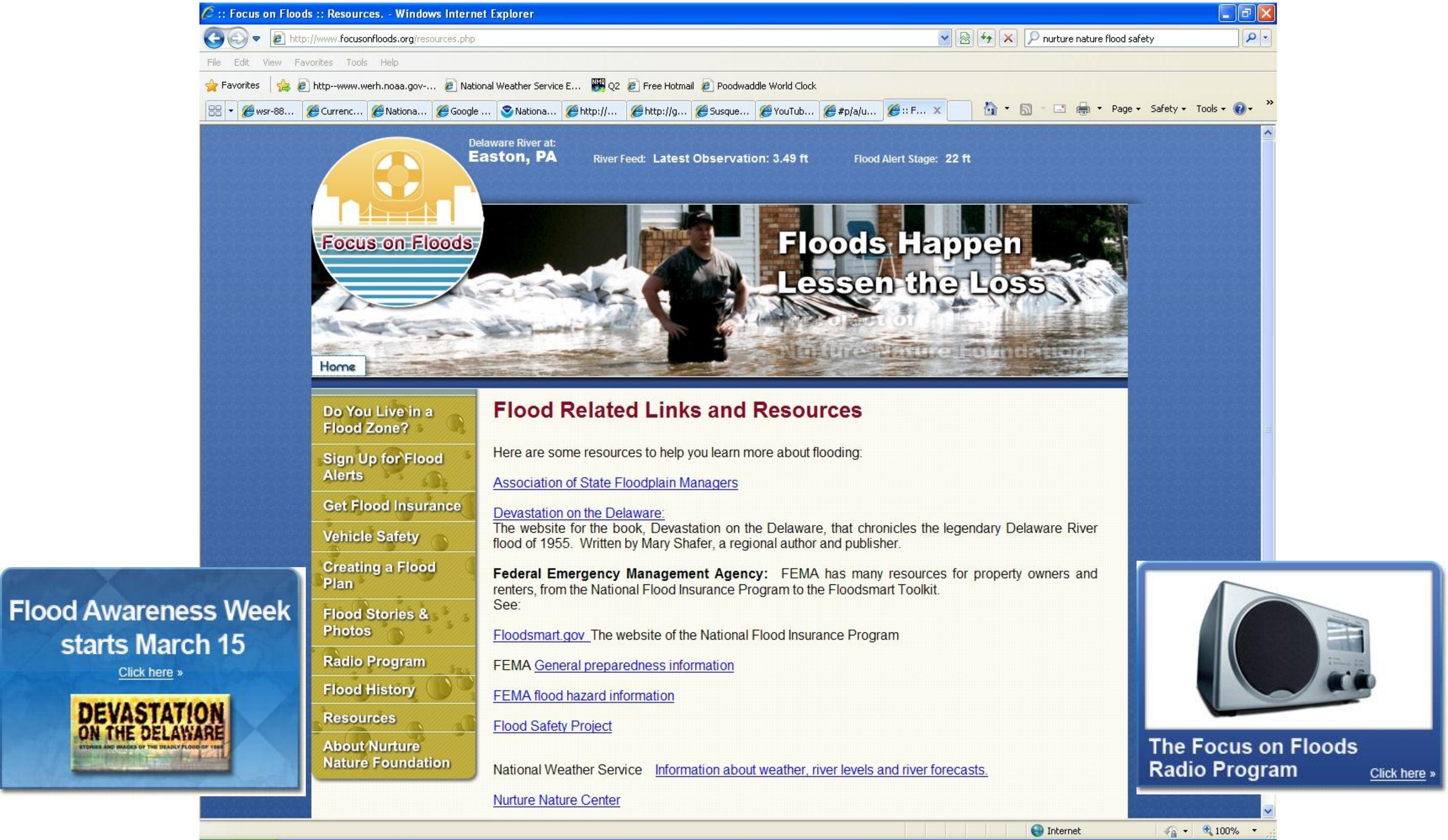
Get Insurance

NATIONAL FLOOD INSURANCE PROGRAM FloodSmart.gov
The official site of the NFIP

Flood Safety Awareness – Public Service Announcements

http://www.youtube.com/user/susquehannariverbc#p/a/u/1/tKQyzRbivWc

Flood Safety Awareness - Nurture Nature Project



http://www.focusonfloods.org/

Flood Safety Awareness - Outreach

Section 6

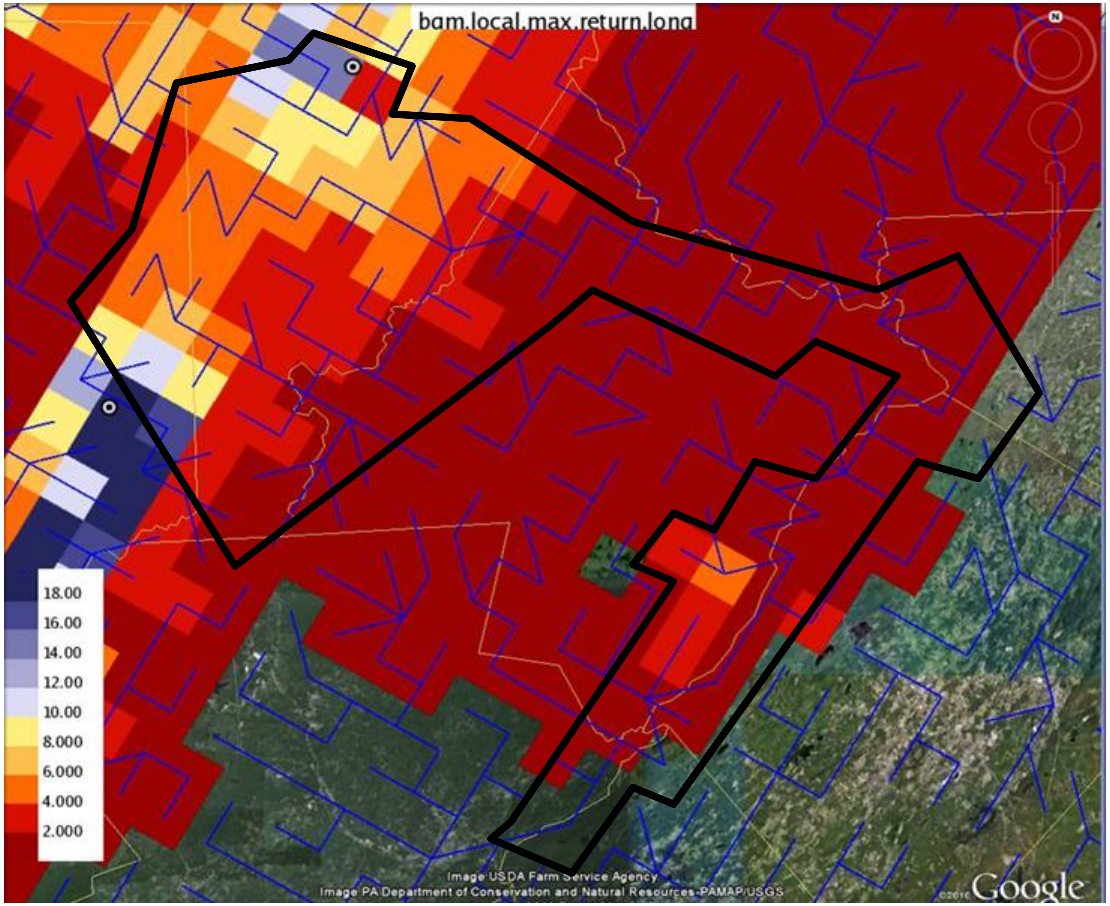
Evolution of Services – Next 5-10 Years

Remaining Flash Flood Challenges

- Analysis and Communication of Location:
  - Unlike river flood warnings for specific points where there is a gage, flash flood warnings occur in small ungaged streams and washes or entirely outside the channel.
  - Flash floods may occur in the immediate vicinity of heavy precipitation, or a significant distance downstream.
- Analysis and Communication of Magnitude
  - River flooding is communicated in terms of minor, moderate, or major flood based on impacts
  - Flash flood warnings are binary and can't distinguish between small scale events that close low water crossings to catastrophic events that devastate entire

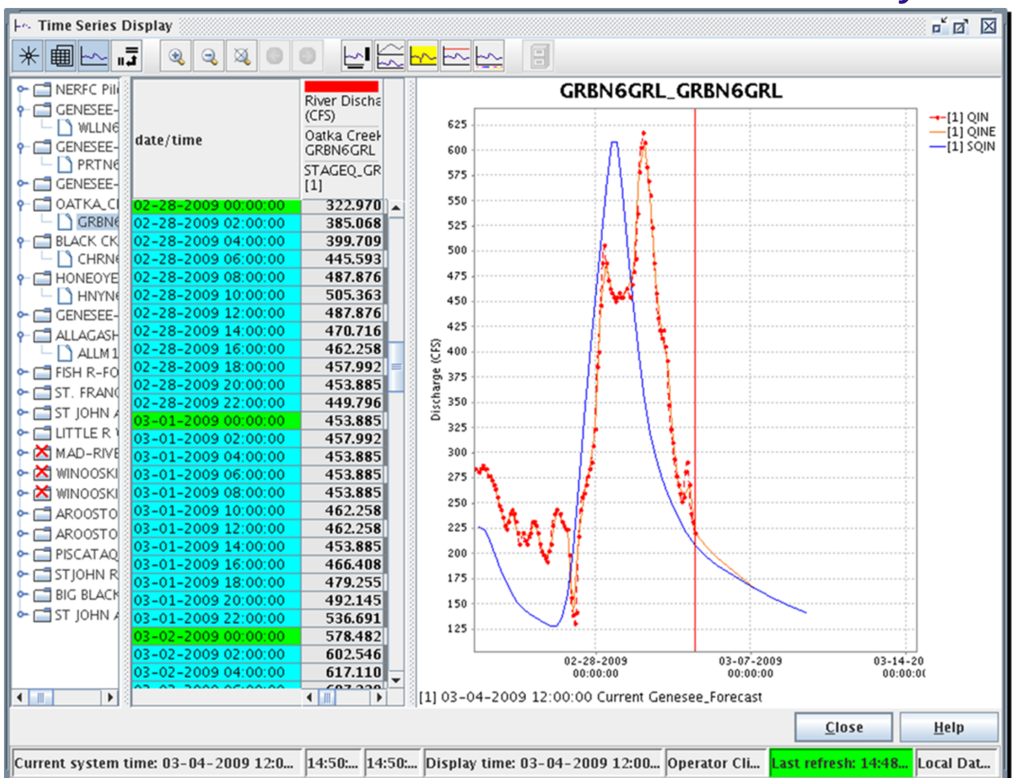
Future Needs

- Accurate Distributed Hydrologic Models
  - Fine Temporal Resolution (hourly or better)
  - Fine Spatial Resolution (4 km or better)



Community Hydrologic Prediction System (CHPS)

- New operational hydrologic modeling software architecture
  - Better integration and leveraging of modeling activities with other water agencies, academia, and the private sector.
  - New hydrologic models can be incorporated easily
  - Client-server connection: WFO forecasters may be able to remotely run a flash flood model resident on the RFC CHPS system.



Integrated Water Resources Science and Services (IWRSS)

Innovative Federal Consortium

- New business model for interagency collaboration
- Common Operating Picture

In-Region Stakeholder Participation

- Deployment of regional service agents
- Integrated use of field offices

New Digital Information Products

- Summit to Sea
- Floods to Droughts
- Past. Present and Future
- High Resolution, Quantify Uncertainty

Single Portal for Water Information

- One-stop shopping
- Federal Toolbox for forecasts, data, maps, policies, programs

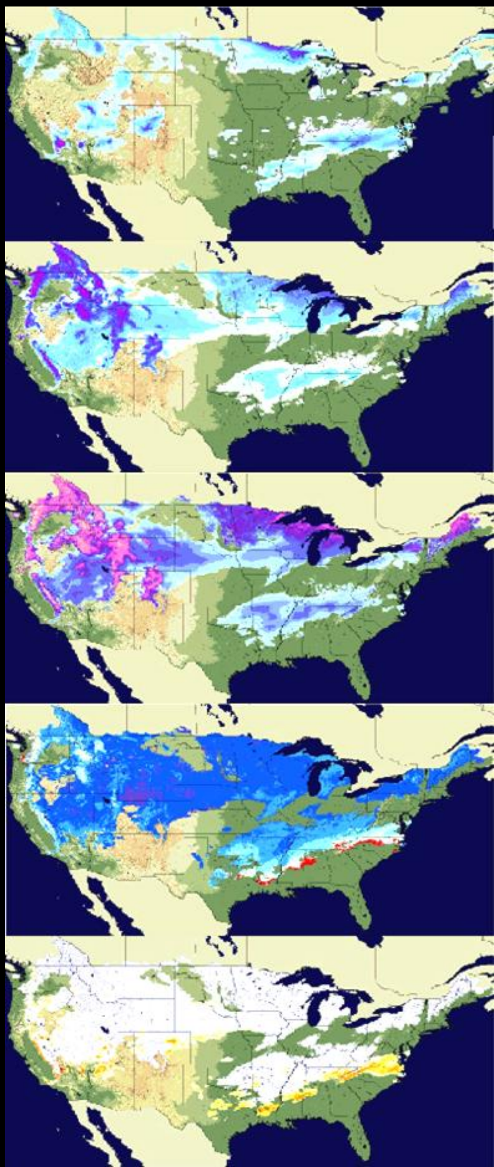
National Water Center

- New bricks and mortar facility
- Synthesis and Integration
- Multi-agency staffing

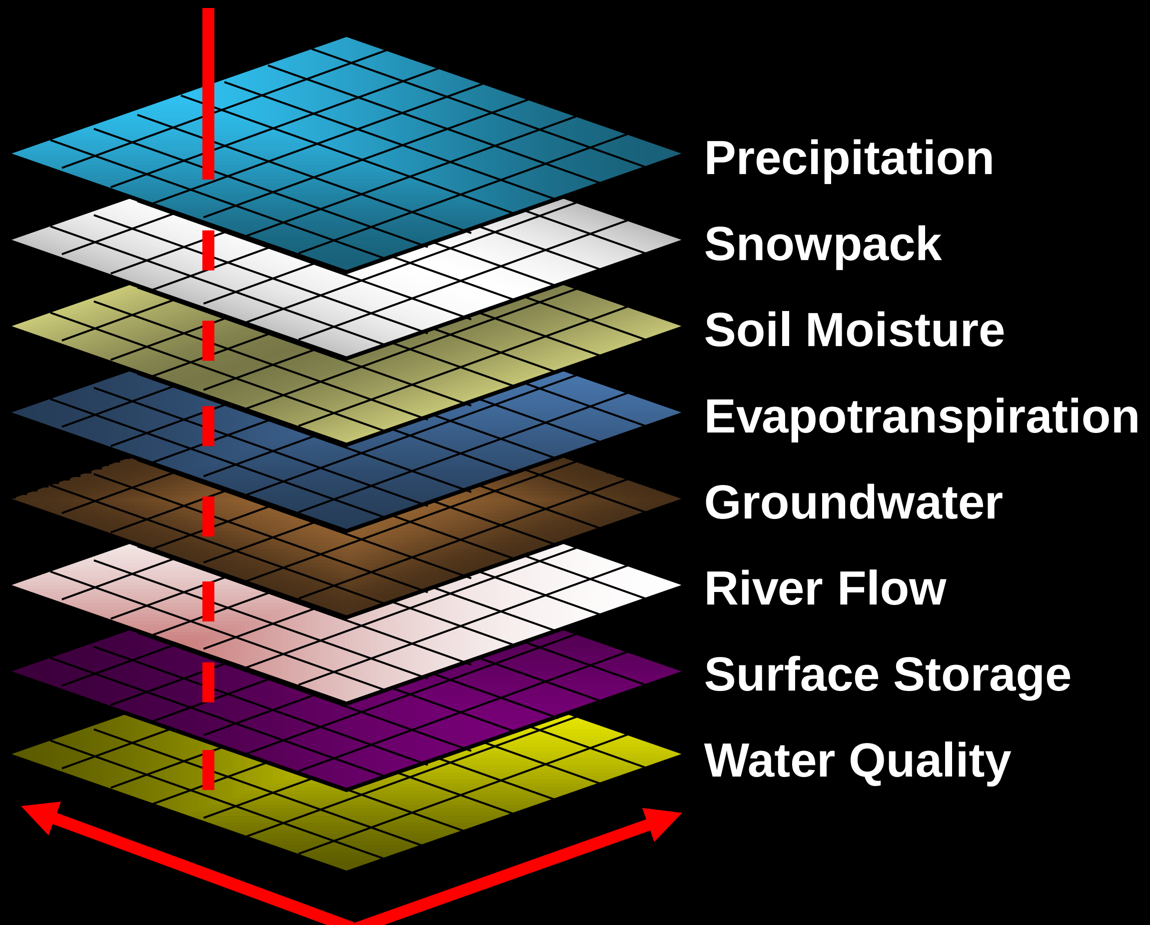
FIVE-POINT STRATEGY

New Digital Information Products

Summit-to-Sea



Local Information (500-meter)



Watershed – to – National Information

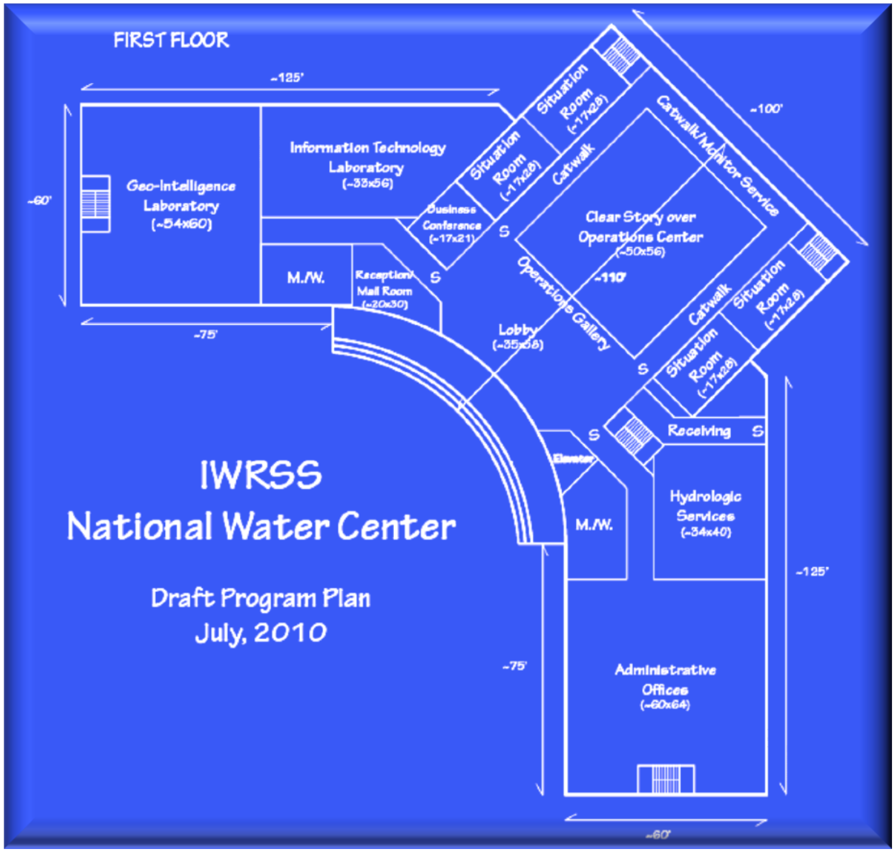
Past Present Future

IWRSS Spiral Path of Development

- Pilot Projects - Build a little, Test a little, Field a little
- MARFC Flash Flood Improvement Pilot - planned
  - Goal – Increase warning lead time and increased ability to distinguish relative magnitude or risk
  - Use latest available high resolution MPE and 0-6 hour QPF forecasts
  - Incorporate QPF forecasts into DHM-TF technique for MARFC area
  - Work with WFO LWX and WFO BGM on useful real-time displays
  - Test use of CHPS Client running at the WFO to access model/displays
  - Test remote CHPS back-up capabilities by running DHM-TF at NOHRSC
  - Verification of results and critical feedback from users and stakeholders

National Water Center

- NOAA facility on campus of University of Alabama
- Only facility in the world to unite water resources forecast operations with research to deliver IWRSS
- Multi-agency staffing
- 24x7 Operations Center
- Science and technology integration



Summary

- NWS Improvements since 1980s have led to improved precipitation measurements, QPF, forecaster analysis tools, warning dissemination methods, and education and outreach.
- NWS plans to take several significant steps over the next 5-10 years
  - Better rainfall estimates from dual pol radar
  - Better 0-3 hour rainfall forecasts by combining multisensor and mesoscale based techniques
  - New CHPS software architecture enabling better collaboration with partners on the use and application of distributed models.
  - IWRSS partnership to better leverage complimentary work and improve data sharing with other federal agencies.
  - Continued development and testing of improved forecaster analysis tools through pilot projects.

Summary

- Substantial flood awareness and education program is key to the success of any warning and response system.
  - Local warning plans need to be reviewed and practiced on a regular basis
  - Awareness and knowledge needs to be prevalent in the community so that safety measures are implemented without delay to prevent loss of life and save property.
- Improvements in Flash Flood Warning Services will help us build a Weather-Ready Nation in the 21st Century!

Thank You!

Contact Information:

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