NOAA's National Weather Service Flash Flood Warning Program

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Photo: Berry Brook flash flood damage. June 19. 2007.

What is a flash flood?

A flash flood is a rapid rise of water along a small stream or in some cases a mainstem river that is a threat to life and/or property.

The rapid rise could be a literal "wall of water" or it could be a rapid rise (e.g. several feet within an hour's time-frame).

Wayne County, PA flood.

Causes of flash flooding

- **Excessive rainfall.**
- **Rain-on-snow.**
- **Rapid snow-melt.**
- **Dam failure.**
- **Levee failure.**

Forecasting a flash flood

Flash flood forecasting involves evaluating a large number of data sources, reports, and programs.

- **Prior conditions**
- **Atmospheric models**
- **Rainfall**
- **Reports of flooding**
- **Stream gages**
- **Model output**
- **Other tools**

NWS Binghamton
flash flood operations

Prior Conditions

- **Streamflow levels**

- **Soil moisture conditions**

Palmer Drought Index
Long-Term (Meteorological) Conditions
November 12, 2006 - November 18, 2006

National Climatic Data Center, NOAA
based on data provided by the
Climate Prediction Center, NOAA
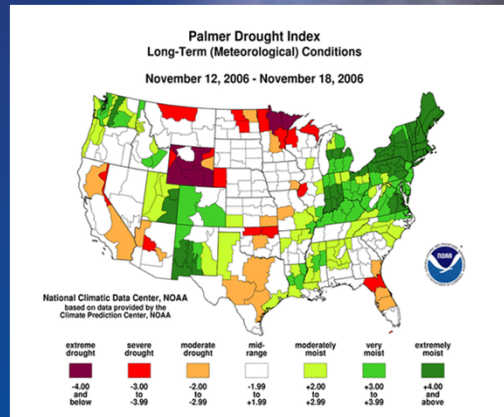
Flash Flood Guidance

- **Is the amount of rainfall over a given period of time required to bring a small stream up to a bankfull condition.**

- **Gives a good approximation for the amount of rain required to begin minor flooding in small streams.**

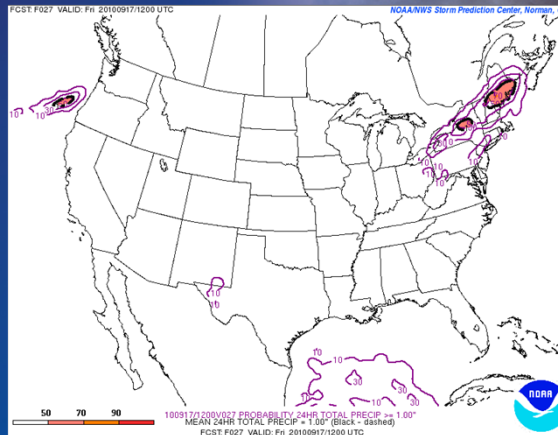
Latest 6 Hour Gridded FFG, Valid 09/24 at 12 UTC
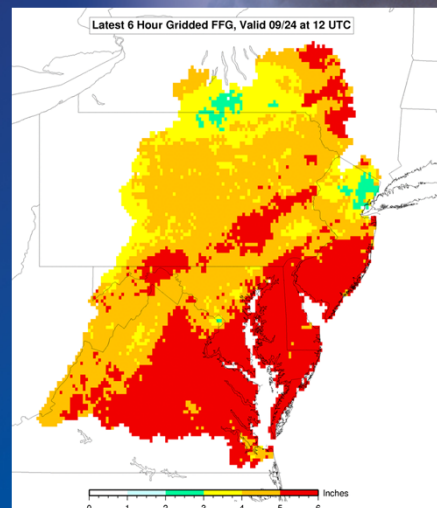
Atmospheric Models

Provide future rainfall forecasts for various time increments (e.g. 6-hours, 24-hours).

Allow forecasters to examine rainfall from multiple atmospheric models. Including probability information.

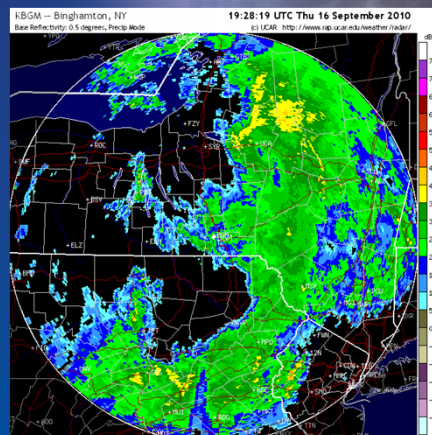Most useful during the watch phase of forecasting.

Rainfall

Sources of Rainfall Data:

- **NWS radar sites**

- **Skywarn spotter rainfall reports**

- **Automated rain gages**

- **Community Collaborative Rain, Hail and Snow (CoCoRaHS) network.**

Reports of Flooding

- **Essential for the NWS to keep updated on what is happening on the ground during an event.**

- **Situational awareness.**

- **Provides info as degree of flash flooding escalates.**

Stream Gages

- **USGS**

- **IFLOWS/ALERT**

Critical for the detection of flash floods in remote portions of the Upper Delaware River Basin.

Model Output

- **Rainfall-runoff model output (River Forecast Center and Weather Forecast Office run).**

- **Flash Flood Monitoring and Prediction (FFMP) program.**

- **Distributed model project (NWS Binghamton portion of the Delaware River Basin).**

Rainfall-Runoff Models

- **Rainfall-runoff models predict flow at a given location in a river system based on:**
  - *Soil moisture conditions*
  - *Current streamflow*
  - *Actual and predicted rainfall*
  - *Many also take into account snowmelt and rain-on-snow scenarios*

Types of Rainfall-Runoff Models

- **Those run at the River Forecast Center**

  - *Output appears on the AHPS web page as an official river forecast*

  - *Includes snow model*

  - *Designed for larger watersheds*

- **Those run at the local Weather Forecast Office**

  - *Output generally not available on the web since it is used as guidance in the issuance of flash flood warnings*

  - *Does not include a snow model*

  - *Designed for smaller faster responding watersheds*

River Forecasts
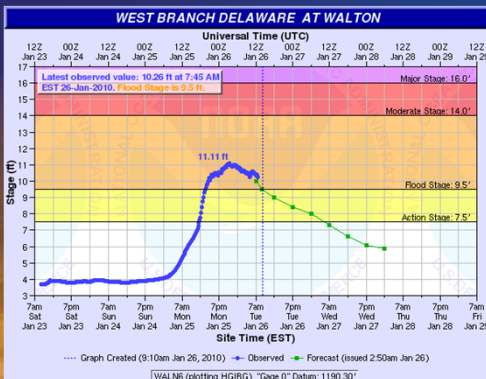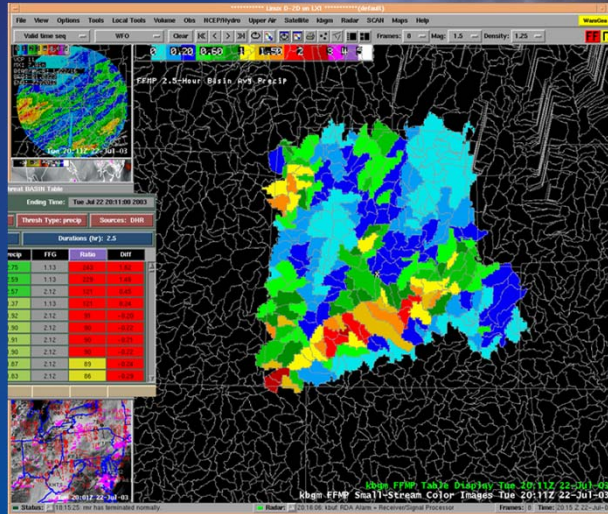
Flash Flood Monitoring and Prediction (FFMP) Program

Looks at watersheds at a scale where flash flood process occur.

Some as small as 2 square miles.

**Takes radar rainfall and maps it to small basins.**

Compares basin averaged rainfall to Flash Flood Guidance issued by the River Forecast Center.

Distributed Modeling Project

- **Breaks the entire Delaware River watershed into a series of grid cells.**

- **Each grid cell provides output in the form of flow return frequency (e.g. 10-year return flow, 50-year return flow, etc.).**

- **Can be applied to both gaged and ungaged locations.**
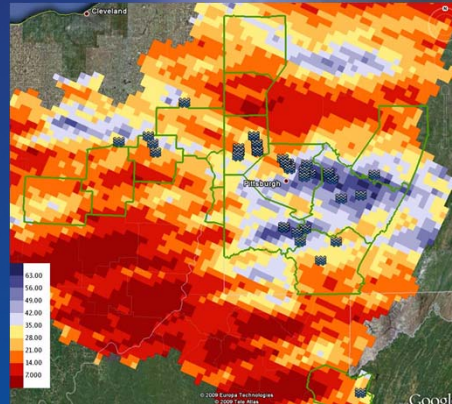
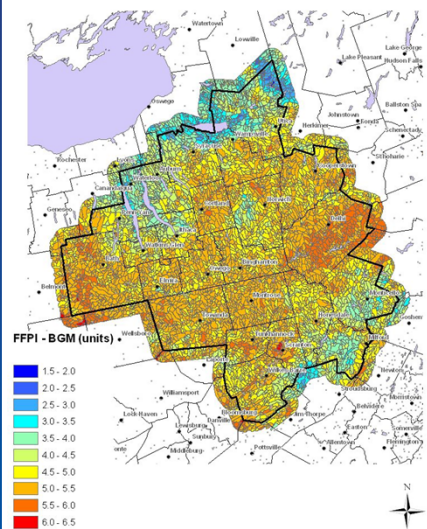Example from NWS Pittsburgh, PA.

Other Tools

- **Flash Flood Potential Index.**

- **Provides a *Qualitative index from 1 to 10 on how susceptible a small watershed is to flash flooding.***

- ***Takes into account GIS data from land slope, soil type, land use, and forest cover.***

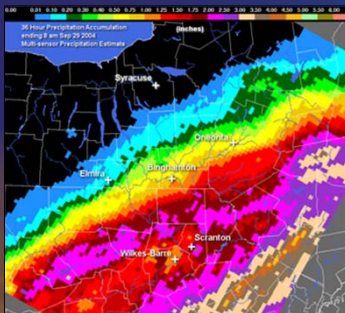- ***Is a static layer and not updated for changes in soil moisture.***

Flash Flood Potential Index (FFPI)

FFPI - BGM (units)

- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- 5.0 - 5.5
- 5.5 - 6.0
- 6.0 - 6.5

Ivan - September 2004

First significant flood since 1996; 1 of 5 tropical systems impacting our Area

- **Demonstrated that flash flooding is common place during a tropical rainfall event.**

- **Flash flooding (i.e. small stream flooding) will typically occur before or at the same time as a mainstem flood event.**

- **Small stream flooding can become a mainstem river flood as water is translated further downstream.**

Delaware County Flash Flood
June 19th, 2007

- 4 dead.

- At least 25 million dollars damage.

- Route 206 destroyed between Roscoe and Downsville

- 3 homes completely washed away.

- 37 severely damaged or destroyed.

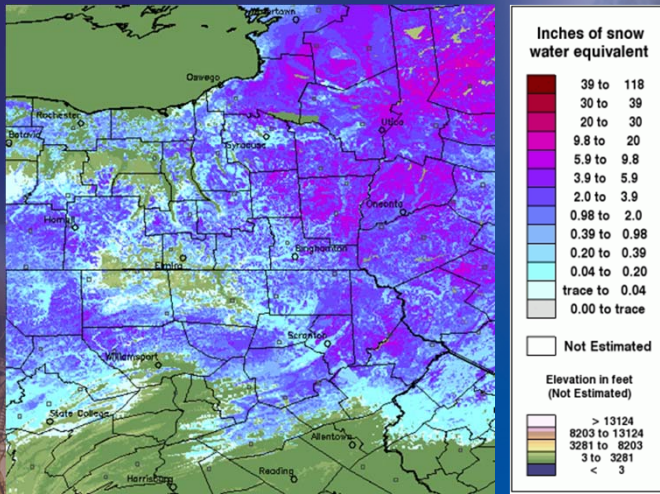- Up to 11 inches rain fell in about 3 hours.

Winter Flash Flooding

- Small stream flooding is common place event during winter due to the potential of rain-on-snow events.

- Frozen ground complicates things even further.

Snow Water Equivalent Data
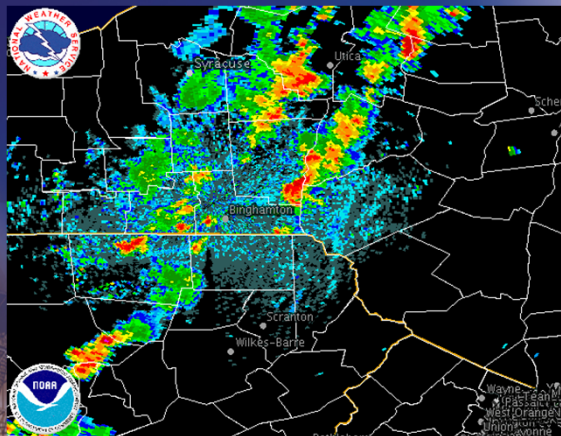

June 19, 2007 Flash Flood

Flash Flood Impacts

- **4 fatalities.**

- **Dozens of homes with some degree of flood damage.**

- **Several homes taken right off their foundations.**

- **Multiple bridge washouts.**

Aerial photograph of lower Spring Brook.
Courtesy of Delaware County.

Radar Loop- "Training" Thunderstorms

NEXRAD LEVEL-II
KBGM - BINGHAMTON, NY
06/19/2007 20:12:06 ...
LAT: 42/12/00 N
LON: 75/59/05 W
ELEV: 1606.0 FT
VCP: 12

REFLECTIVITY
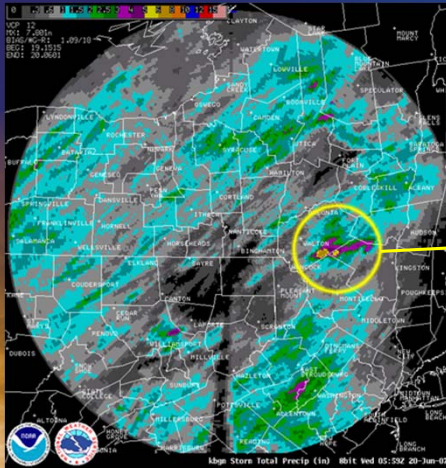ELEV ANGLE: 0.44
SCAN TIME: 20:12:05

Legend: (Category) dBZ

>= + 75
+ 70
+ 65
+ 60
+ 55
+ 50
+ 45
+ 40
+ 35
+ 30
+ 25
+ 20
+ 15
+ 10
+ 5
<= 0

**Flash Flood Forecasting
Doppler radar estimate of Rainfall
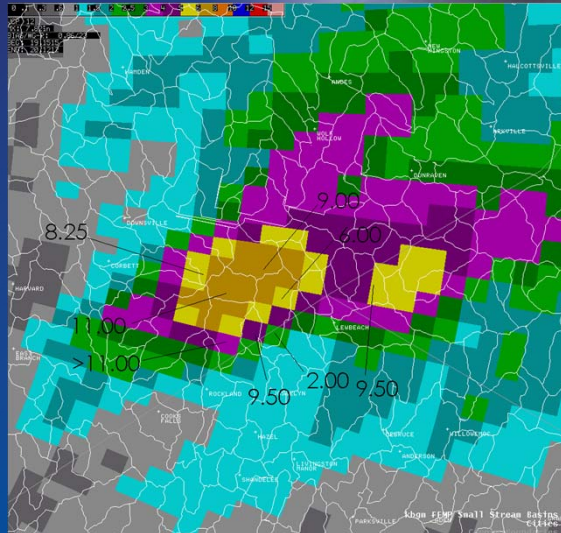June 19, 2007**

Radar indicates 5 to 8 inches of rain within 3 hours.

Bucket Survey Results

- **NWS conducted a bucket survey with the assistance of local residents.**

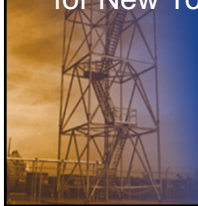- **Results show radar underestimated rainfall.**

Magnitude of Flash Flooding

Indirect estimate yielded a total estimated discharge of 2,771 cfs for Berry Brook.
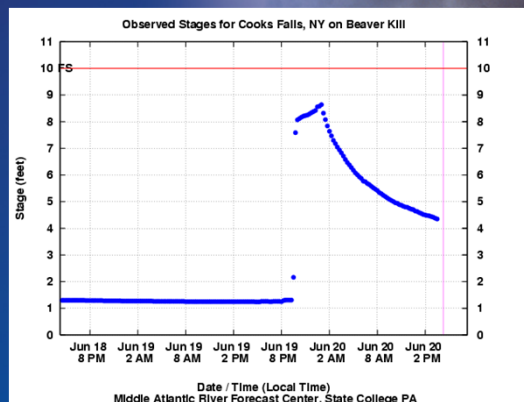
This amounts to greater than a 500-year flow (using USGS regression equations for New York).

Downstream Response

- Experienced a rapid rise of 5.4 feet / 5,000 cfs in a 15-minute time-frame.

- USGS crest stage gage recorded a peak of 10.16 feet / 9.900 cfs.

- Real-time USGS gage failed to capture the peak. A common occurrence during extreme flash flood events.

- Eyewitness reports of a "wall of water" at Roscoe New York and points further upstream.


Observed Stages for Cooks Falls, NY on Beaver Kill
Stage (feet)
Date / Time (Local Time)
Middle Atlantic River Forecast Center, State College PA

News Tools to Model Watersheds impacted on June 19, 2007

- **NWS Binghamton is running the KINEROS model on Spring Brook and Berry Brook.**

- **KINEROS is a distributed model designed to provide guidance on flash flooding in small streams.**
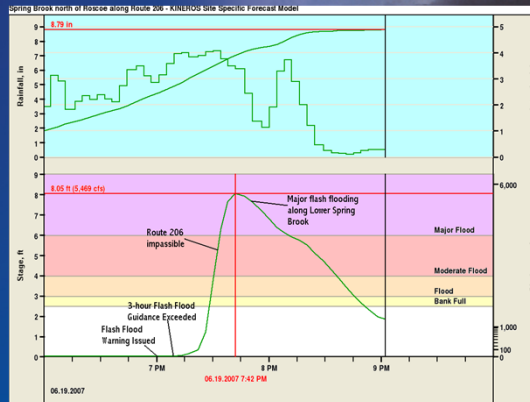
Establishment of new Flood Stages

- **NWS Binghamton has been working to establish flood stages for small stream locations throughout the basin.**

- **East Brook near Walton, NY**

- **Tremper Kill near Andes, NY**

- **Trout Creek near Trout Creek, NY**

- **Dyberry Creek near Honesdale, PA**

Summary

- **Flash Flood forecasting involves a wide variety of data sources and modeling tools.**

- **Relies on ground truth in the form of rain gage reports and reports of flooding/flash flooding.**

- **Is progressing forward with more site-specific / basin-specific information.**

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