

OVERVIEW OF FLASH FLOOD GUIDANCE SYSTEM PRODUCTS

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Haiti and Dominican Republic Flash Flood
Initial Planning Meeting

September 7th to 9th , 2016

Hydrologic Research Center
<http://www.hrcwater.org>



Haiti and Dominican Republic Flash Flood Guidance System

Program Partners



Hydrologic Research
Center



USAID/Office of U.S. Foreign
Disaster Assistance



National Oceanic and Atmospheric
Administration/National Weather Service



World Meteorological
Organization

Overview

- 1. Floods and flash floods in perspective**
- 2. Impacts of Flooding**
- 3. Basic Meteorology of rainfall systems causing flash floods**
- 4. Basic river Hydrology from a flash flooding perspective**
- 5. Forecasting Flash Floods**
- 6. Conclusions**

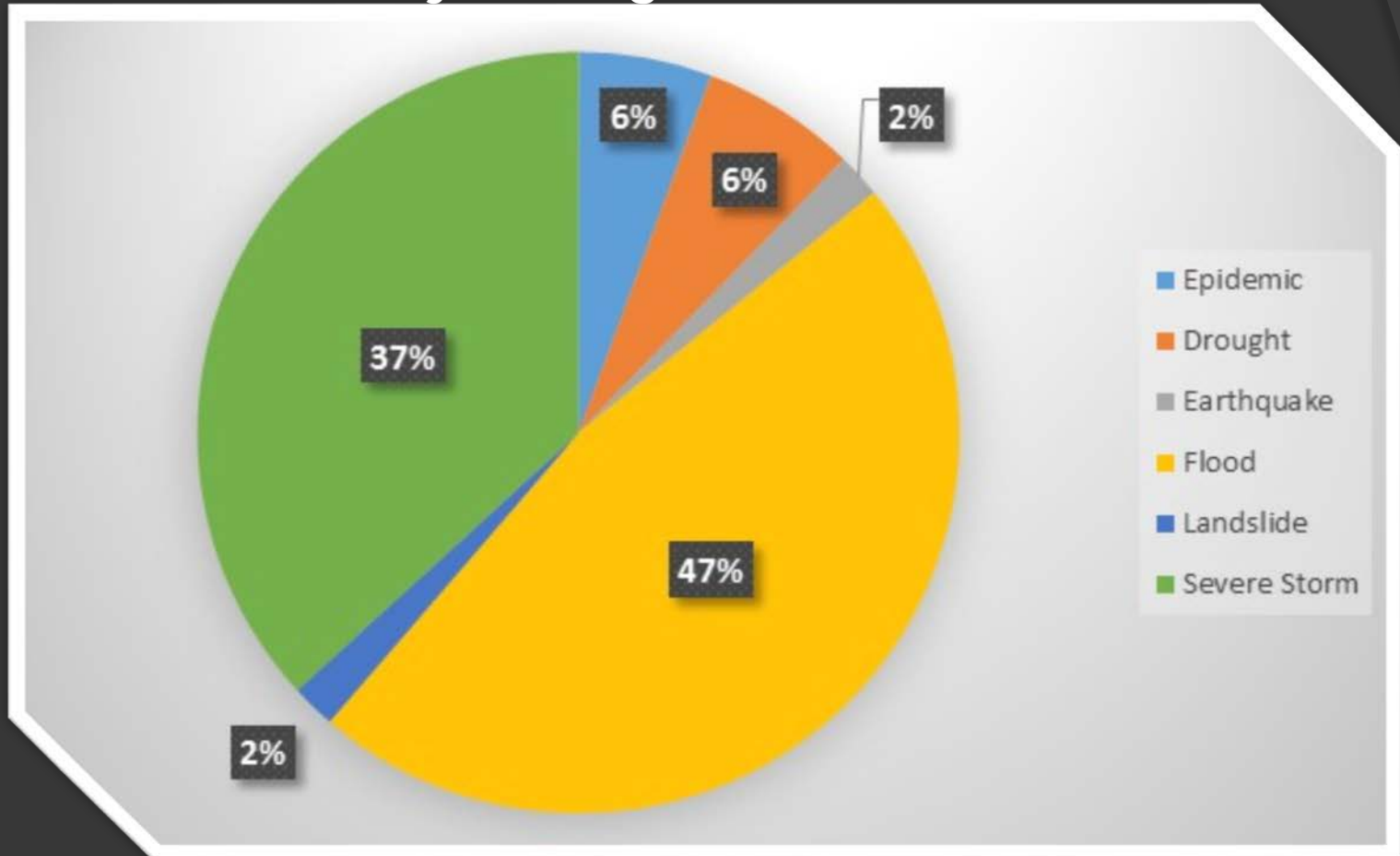


1. Floods and flash floods in perspective

Hazard Analysis

Haiti and Dominican Republic

Major Categories 1900-2015

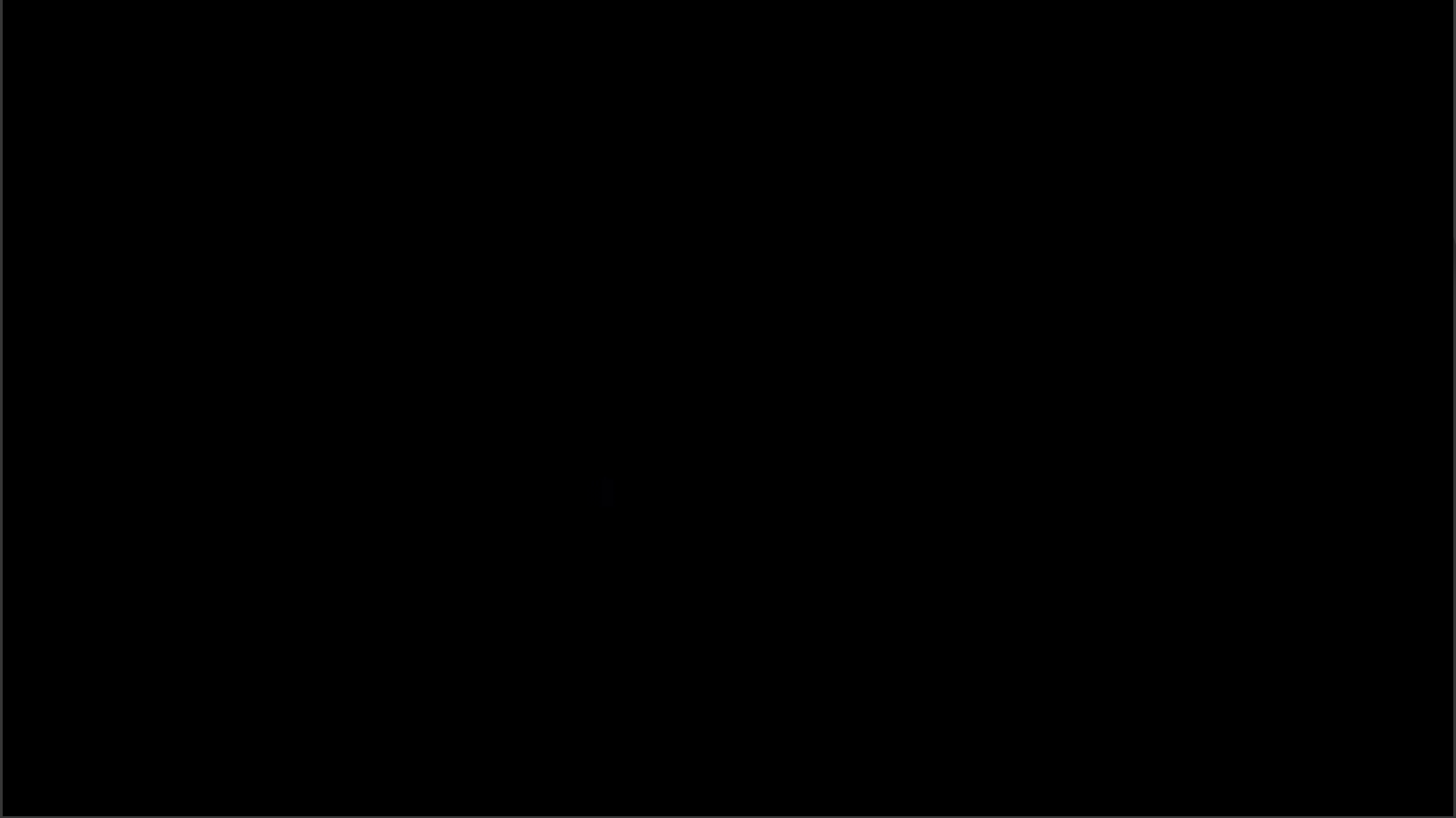


The Need

Flash floods are a world-wide hazard – and rarely a day goes by without news of a flash flood somewhere in the world.

- Highest number of deaths per people affected
- No flash flood warnings for vast populated areas of the world
- Lack of local expertise and of regional cooperation
- Little in situ data in small regions
- Large-river flood-warning strategies ineffective for flash floods
- Climatic changes in several regions increase precipitation intensity

River Floods



Are caused by heavy rain over long periods (days) in the upper catchment leading to rising waters and eventual bank overflow as the flood wave moves downstream. It can take a flood wave a number of days to move down river.

Flash Floods



- World Meteorological Organization - A flood of short duration with a relatively high peak discharge
- American Meteorological Society – A flood that rises and falls quite rapidly with little or no advance warning, usually as the result of intense rainfall over a relatively small area
- Response time is 6 hours or less

Flash Floods in Perspective



Where as river flood forecasting is generally a *Hydrological* problem, flash flood forecasting is a *Hydro-meteorological* problem.





2. Impacts of Flooding

Impacts of Floods

- Social impacts
 - ✓ Drownings and displaced people,
 - ✓ Houses and dwelling destruction,
 - ✓ Road damages leading to communities cut-off from aid
- Health impacts
 - ✓ Epidemics – cholera, diarrhea, malaria outbreaks
- Hydrological impacts
 - ✓ Drinking water quality problems, borehole contamination
 - ✓ Water supply disruptions
- Agricultural impacts
 - ✓ Crop losses, food security problems









3. Basic Meteorology of rainfall systems causing flash floods

Some Prominent Weather Patterns Causing Weather Related Disasters

Some of the Dominican Republic and Haiti's rainfall is caused by the following triggering mechanisms:

- Hurricanes
- Tropical Storms
- Thunderstorms
- Easterly Wave

HURRICANES





TROPICAL STORMS

THUNDERSTORMS



But

"The total number of storms and hurricanes is not nearly as important as the number that hit you, it just takes one."

(Ed Rappaport, acting director of the National Hurricane Center)



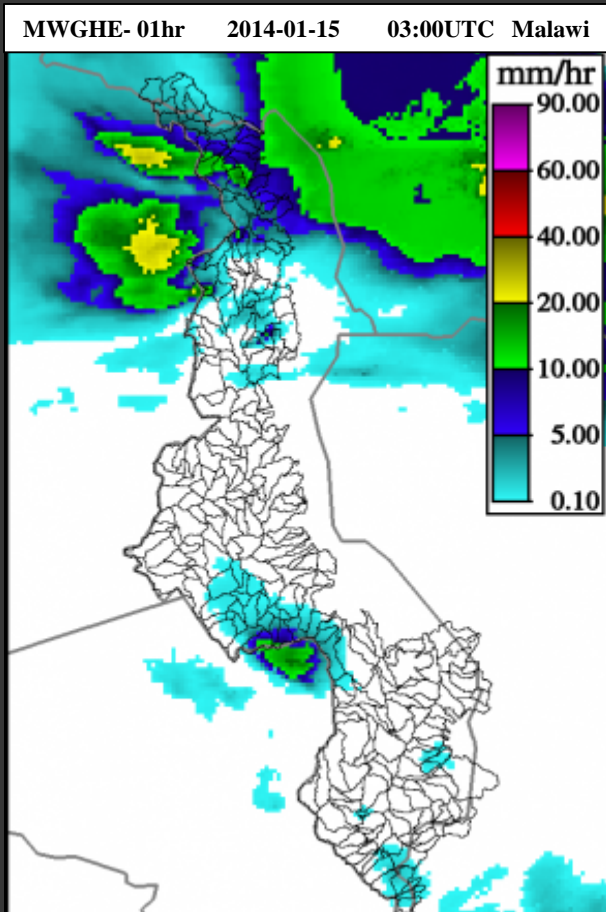
So in summary

In order for a flash flood to occur, heavy precipitation must fall in a region that has appropriate hydrological ingredients in place.

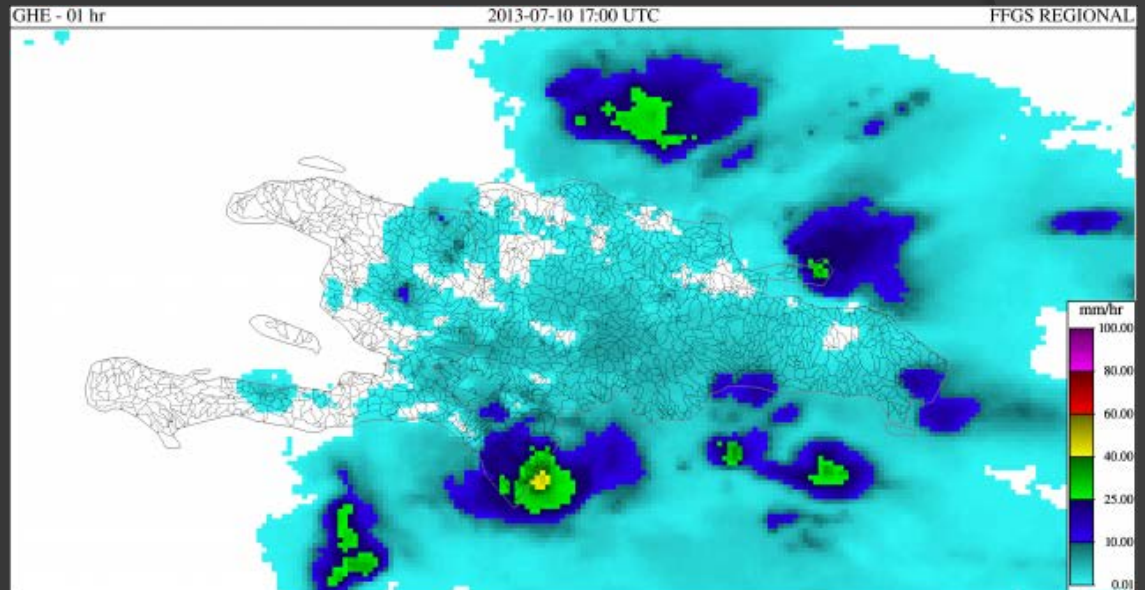
For heavy precipitation to occur, high rainfall rates must be sustained.

Long duration of high rainfall rates results from slow movement of the rainfall-producing system.

The flash flood guidance system offers products to assist forecasters

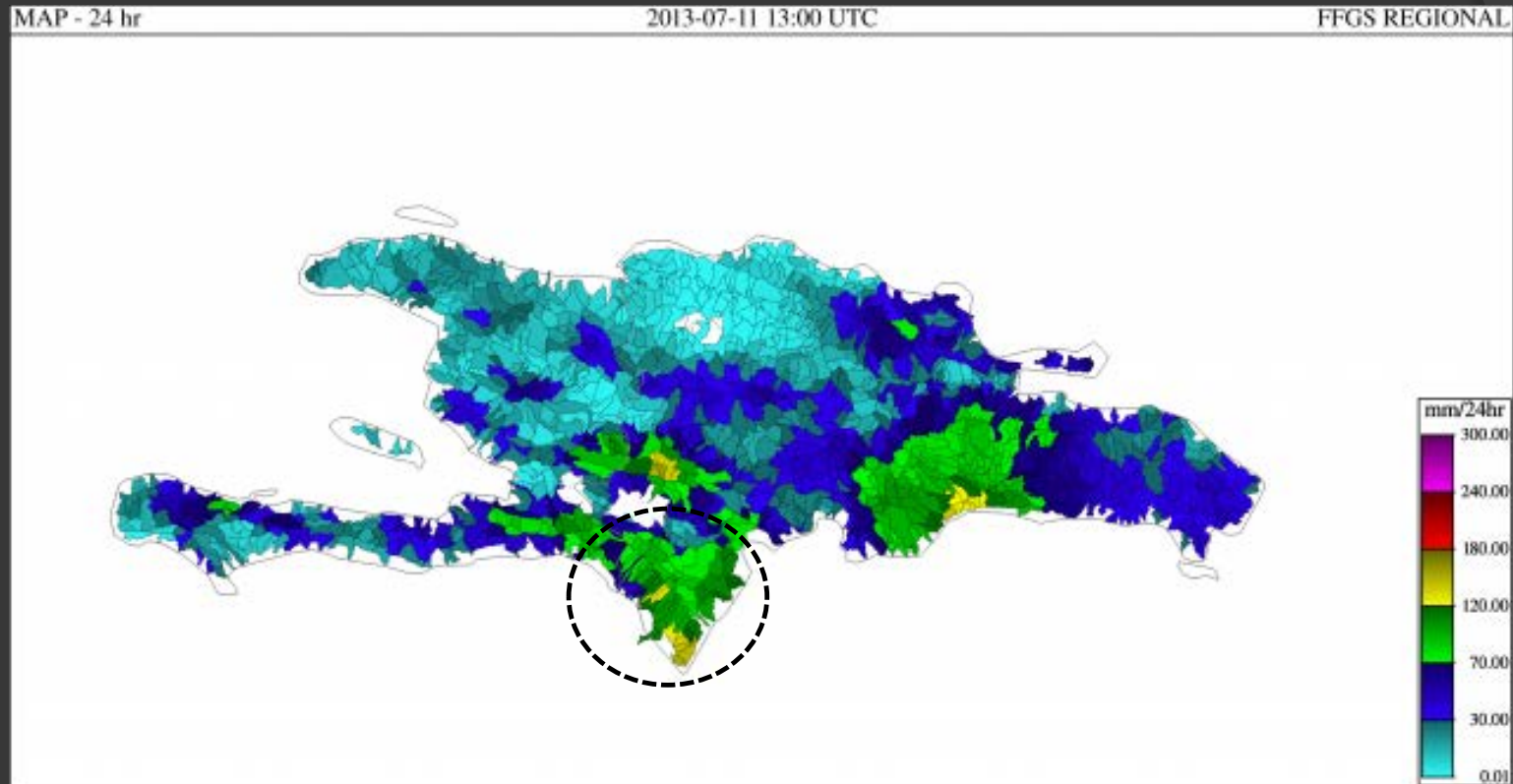


The Microwave-adjusted Global HydroEstimator satellite-based product provides accumulations of infrared-based precipitation (mm).



The Global HydroEstimator (GHE) satellite-based product provides accumulations (mm) of satellite-based precipitation.

The flash flood guidance system offers products to assist forecasters



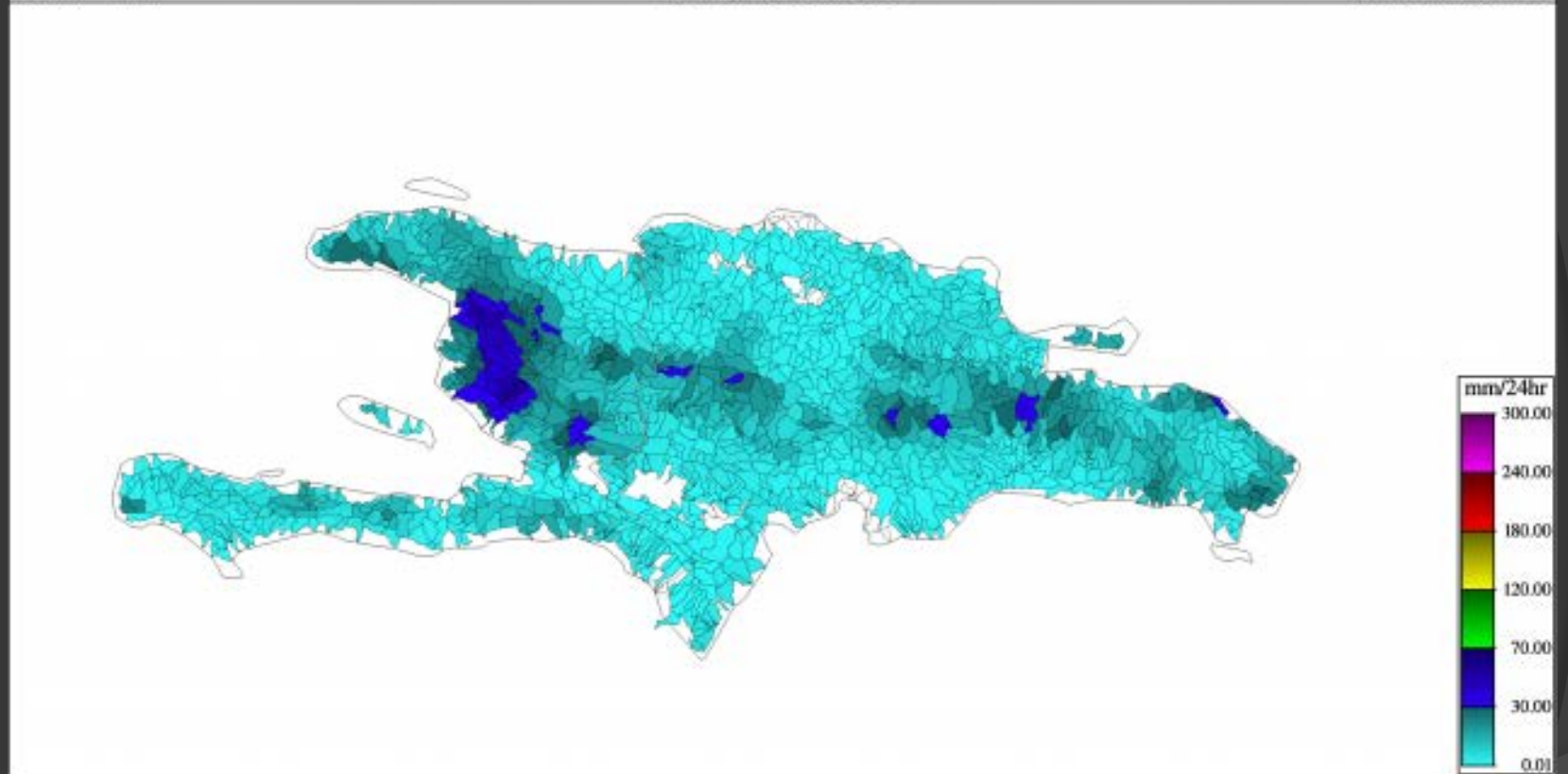
The Merged Mean Areal Precipitation (MAP) product is derived for each basin and is based on the best available mean areal precipitation estimates from the GHE and gauges.

The flash flood guidance system offers products to assist forecasters

FMAP - 24 hr

2015-06-18 16:00 UTC

FFGS REGIONAL



The Forecast Mean Areal Precipitation (FMAP) product reflects rainfall accumulations produced using numerical forecasts of basin-average precipitation.



4. Basic river hydrology from flooding perspective

Flash floods are not generated purely by intense rainfall but also by the hydrologic processes of the land surface on which the rainfall occurs.

It is the interaction between meteorology and hydrology of a location - where the complex interrelationships between:

- atmospheric moisture,
- the terrain,
- soil moisture content,
- and geomorphology

can result in the enhancement of the runoff potential of a given rainfall event, increasing the likelihood of a flash flood event.



Dependent on two factors:

1) is the rainfall rate and the ability for the ground, rivers and streams to absorb the water and

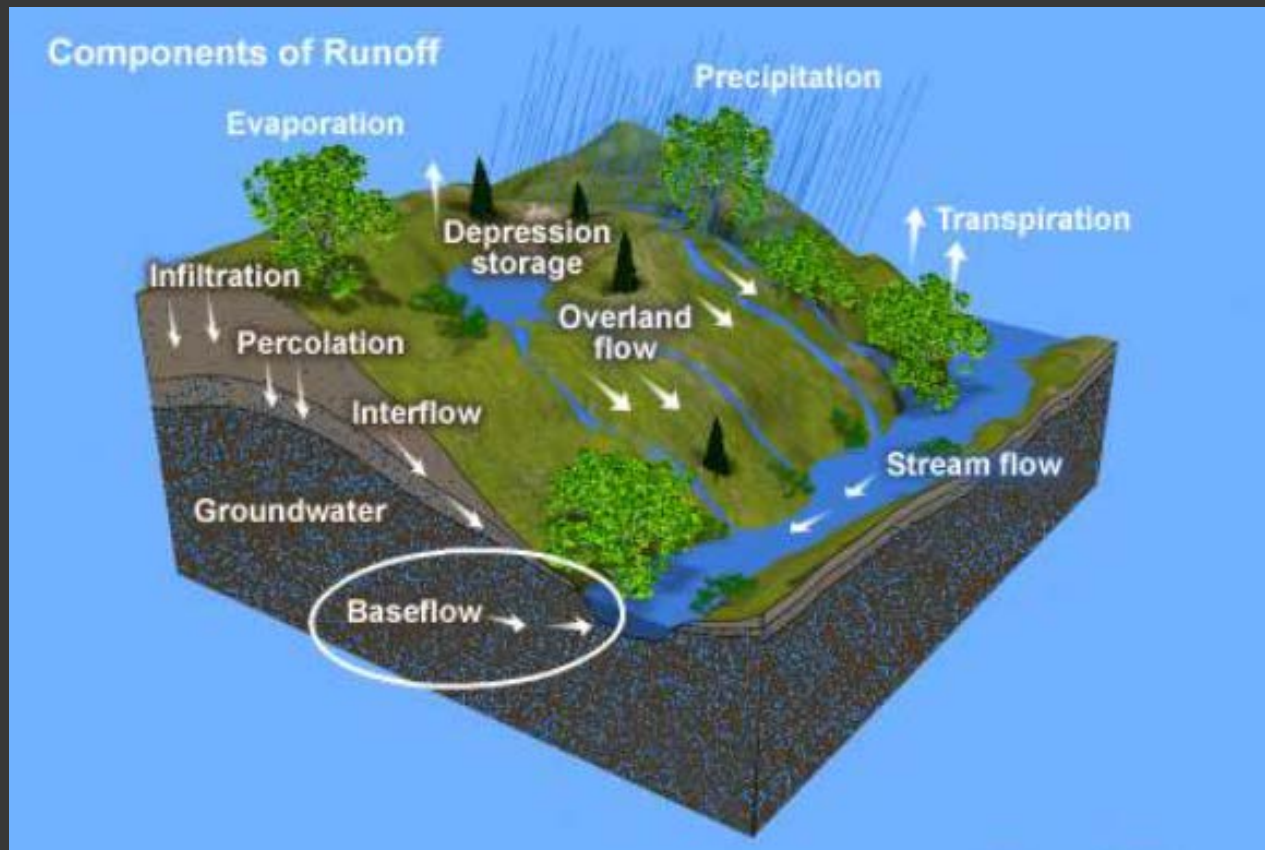
2) the amount of water that is already stored in the ground or moving through the rivers and streams.



Hydrologic modeling of flash floods includes information on:

Hydrological process including components of the hydrologic cycles, rainfall-runoff processes, evaporation, infiltration and groundwater flow, water budgets, surface and sub-surface hydrology.

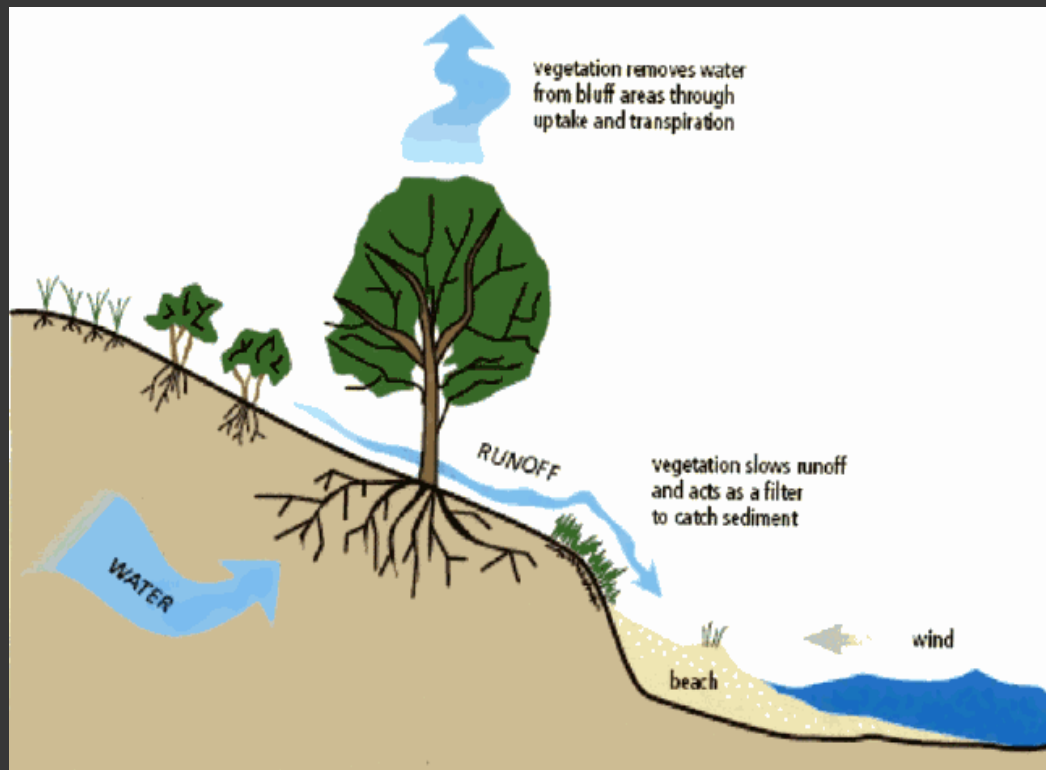
Volume = inflow – outflow of a system



THIS IS KEY INFORMATION FOR FLOOD AND FLASH FLOOD FORECASTING

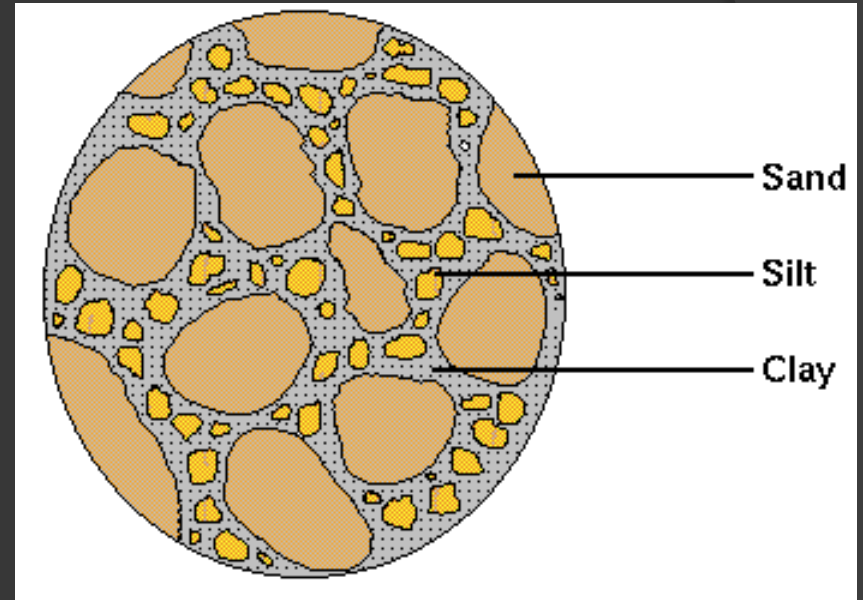
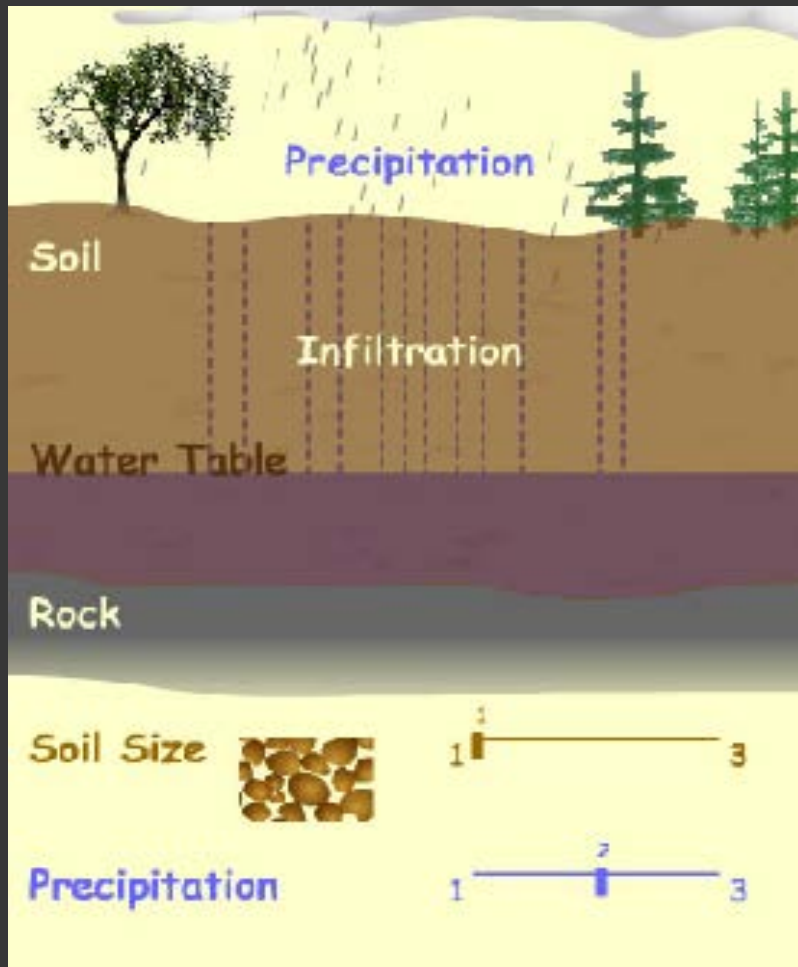
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Also needed is information on stream flow data networks, and detailed descriptions of the river basins, including vegetation types,



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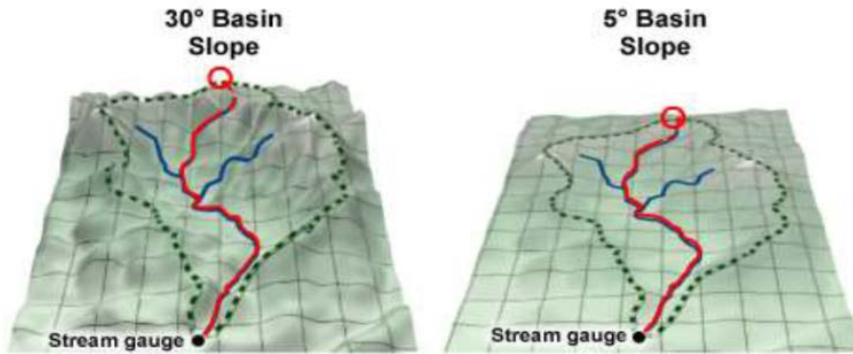


Hydrologic modeling of flash floods includes information on:

Also needed is information on stream flow data networks, and detailed descriptions of the river basins, including vegetation types, soil types, topography, basin size, shape, slope.

- affects amount and timing of runoff

Influence of Basin Slope on Runoff

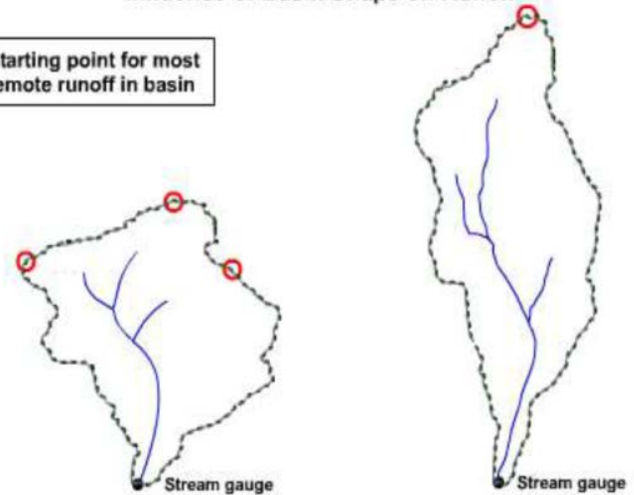


○ - Starting point for most remote runoff in basin

influences magnitude and timing of peak flow

Influence of Basin Shape on Runoff

○ - Starting point for most remote runoff in basin

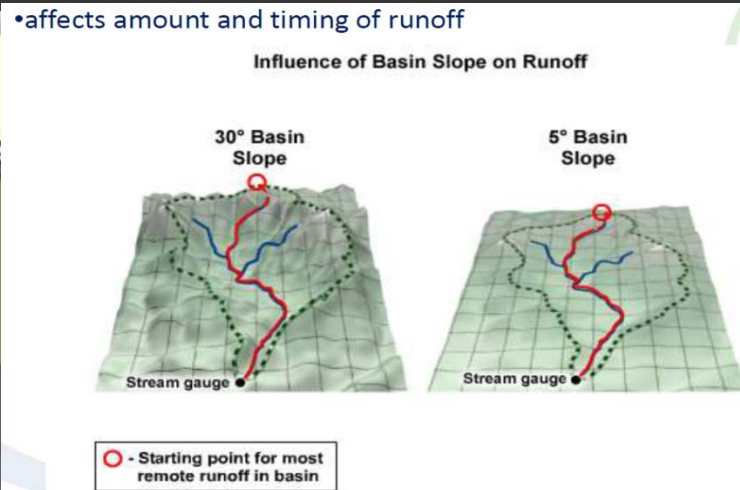
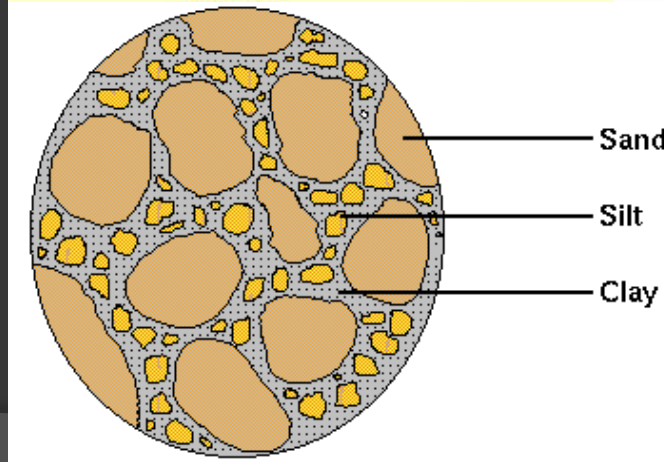
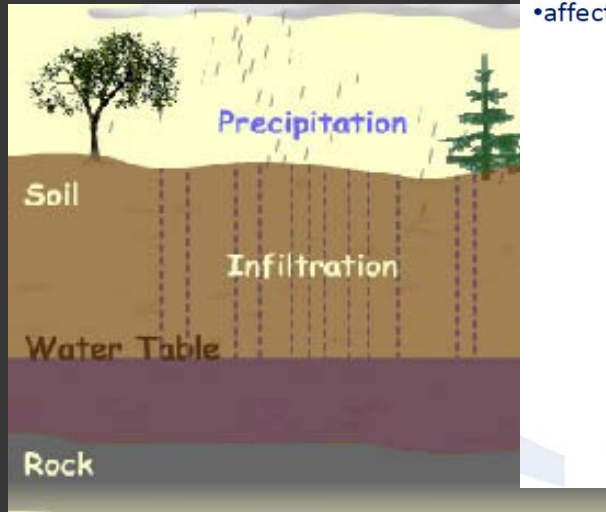


Shorter distance, less travel time

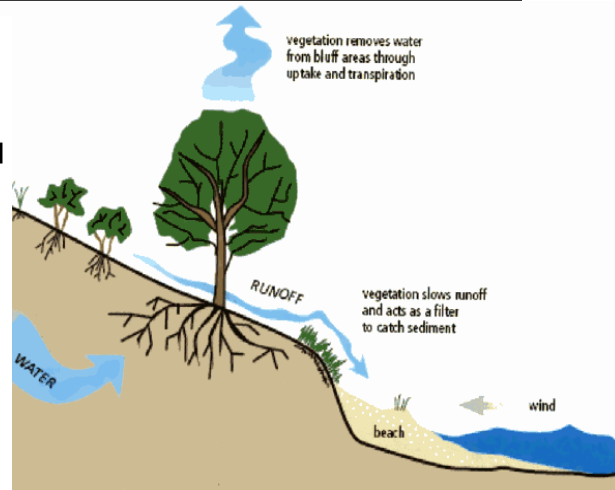
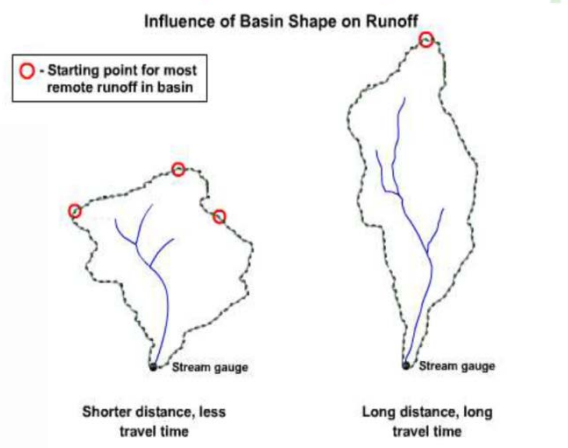
Long distance, long travel time

Hydrologic modeling of flash floods includes information on:

Also needed is information on stream flow data networks, and detailed descriptions of the river basins, including vegetation types, soil types, topography, basin size, shape, slope.



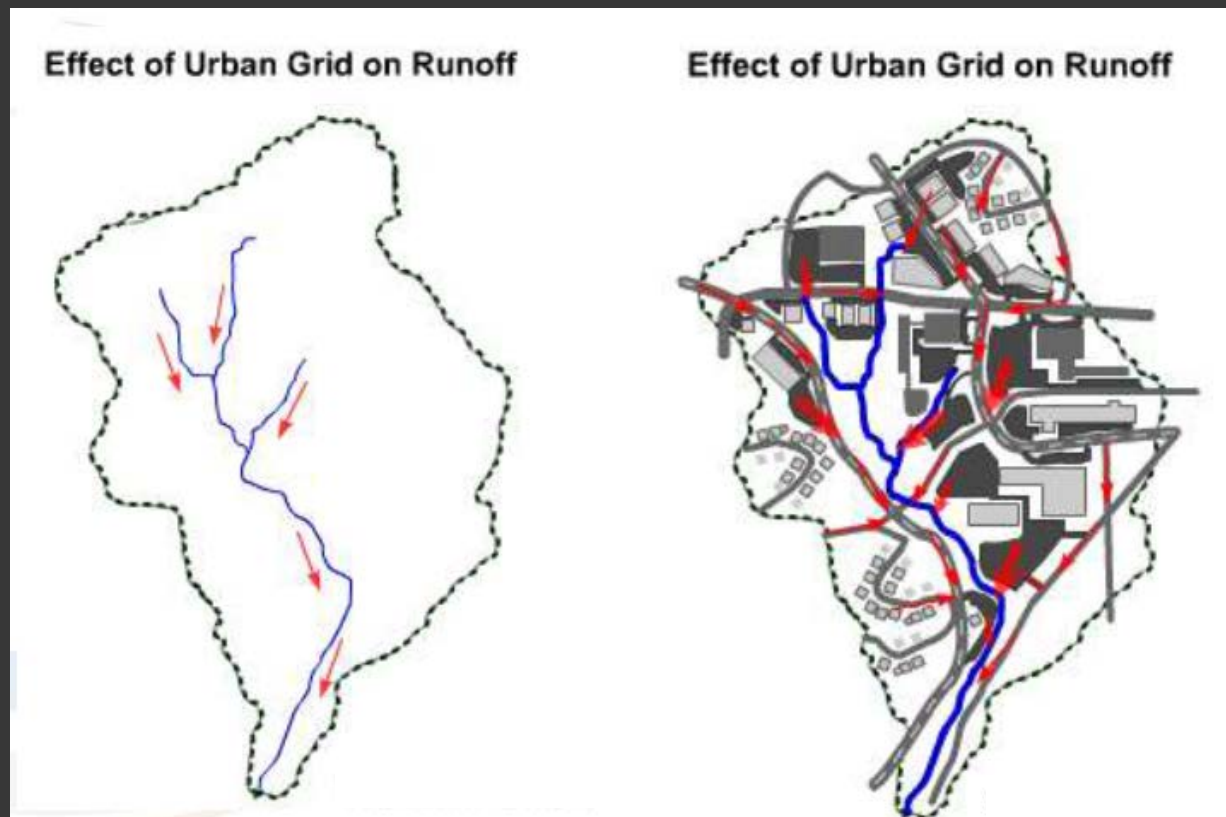
influences magnitude and timing of peak flow



Urbanization

Results in changes of the natural ground surfaces and stream channels of the basin, permeability, roughness, etc.

Road and storm sewer systems add to stream density, resulting in more rapid runoff to stream channels (also because of decreased roughness)

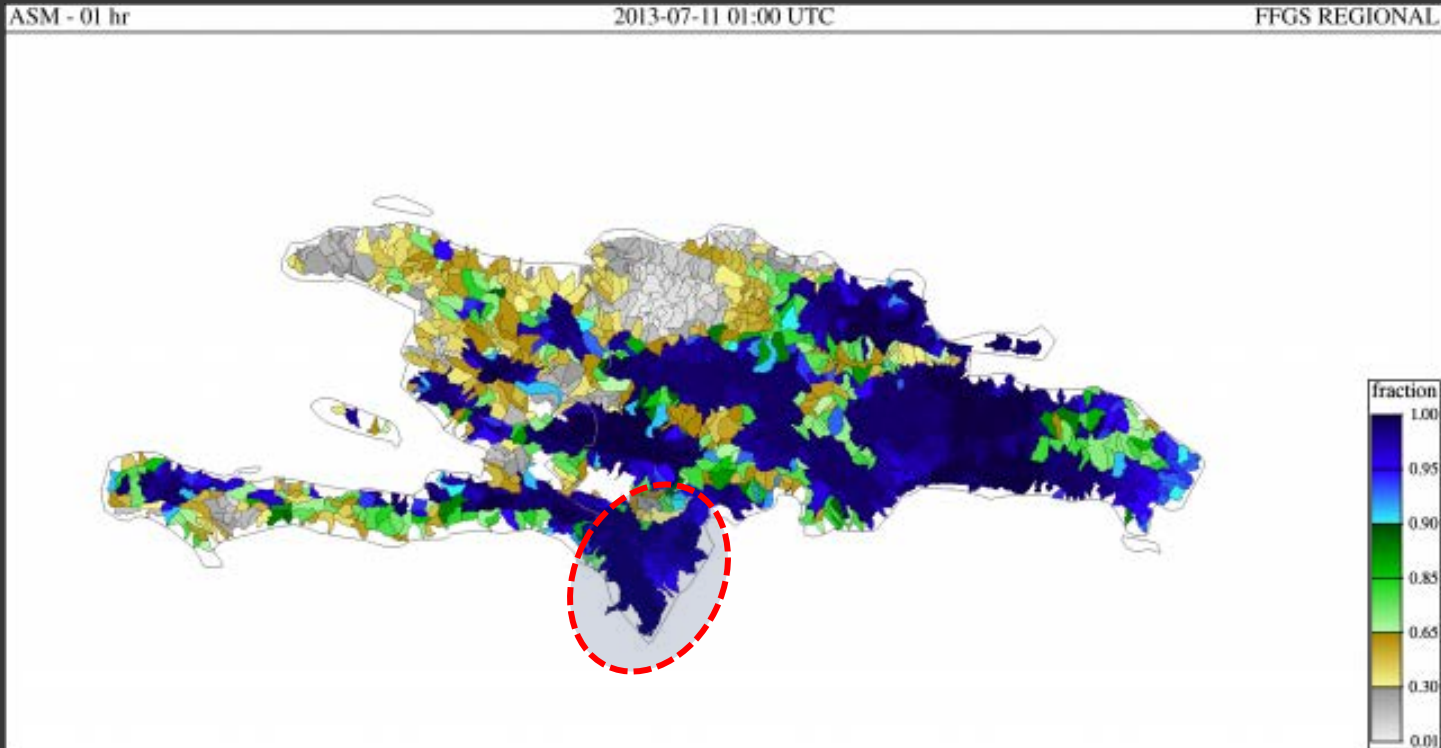


So in summary

Flash floods are phenomenon in which the important hydrologic processes are occurring on the same spatial and temporal scales as the intense precipitation.

These include components of the hydrologic cycle, rainfall-runoff processes, evaporation, infiltration and groundwater flow, water budgets, surface and sub-surface hydrology, and properties unique to flash floods.

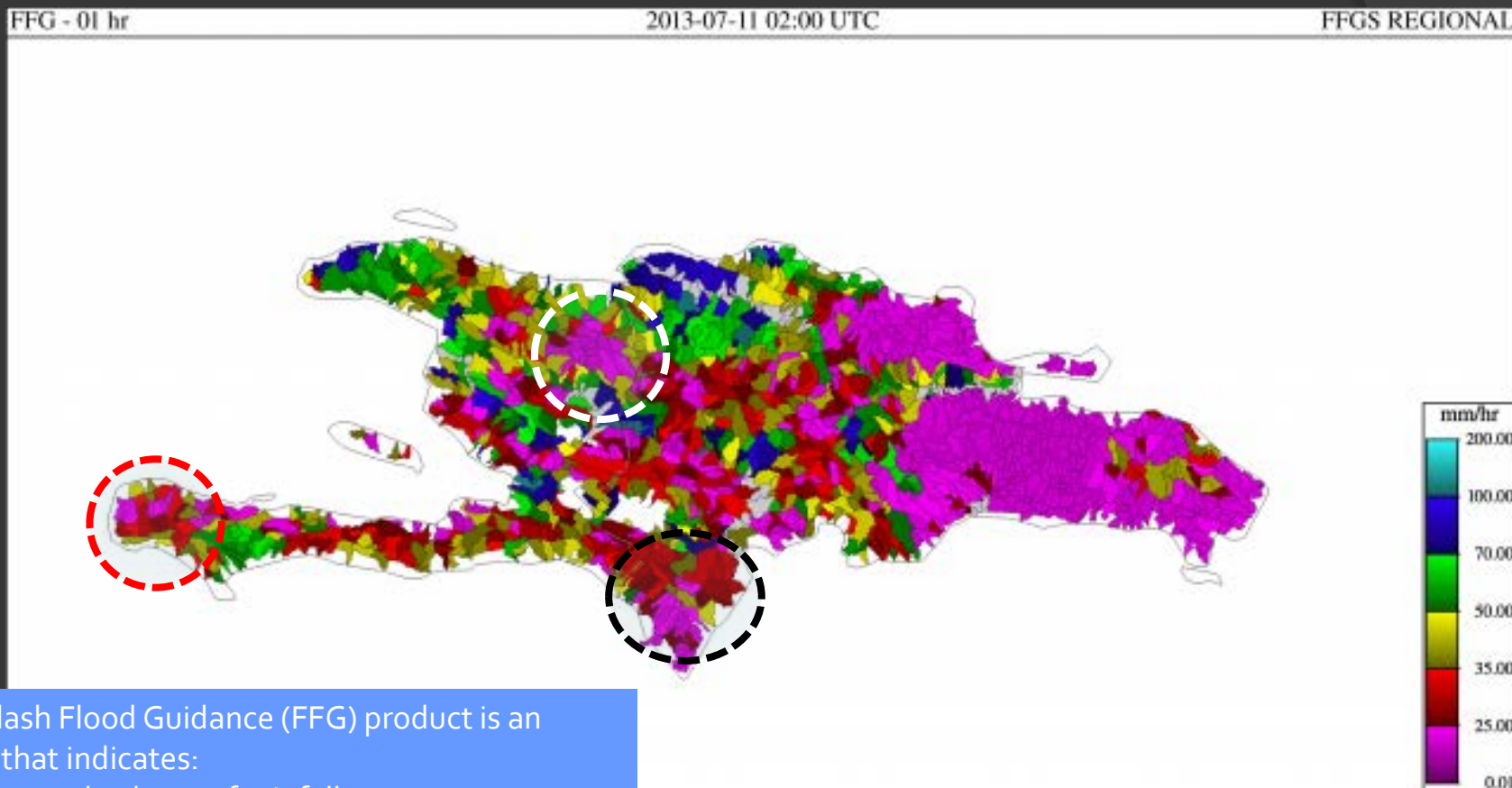
The flash flood guidance system offers products to assist forecasters



Average Soil Moisture (ASM) product provides soil water saturation fraction for the upper zone (about 20-30 cm depth) for each of the sub-basins.

The flash flood guidance system offers products to assist forecasters

The Flash Flood Guidance (FFG) is the key product in the determination of flash flood potential when using the FFG system.

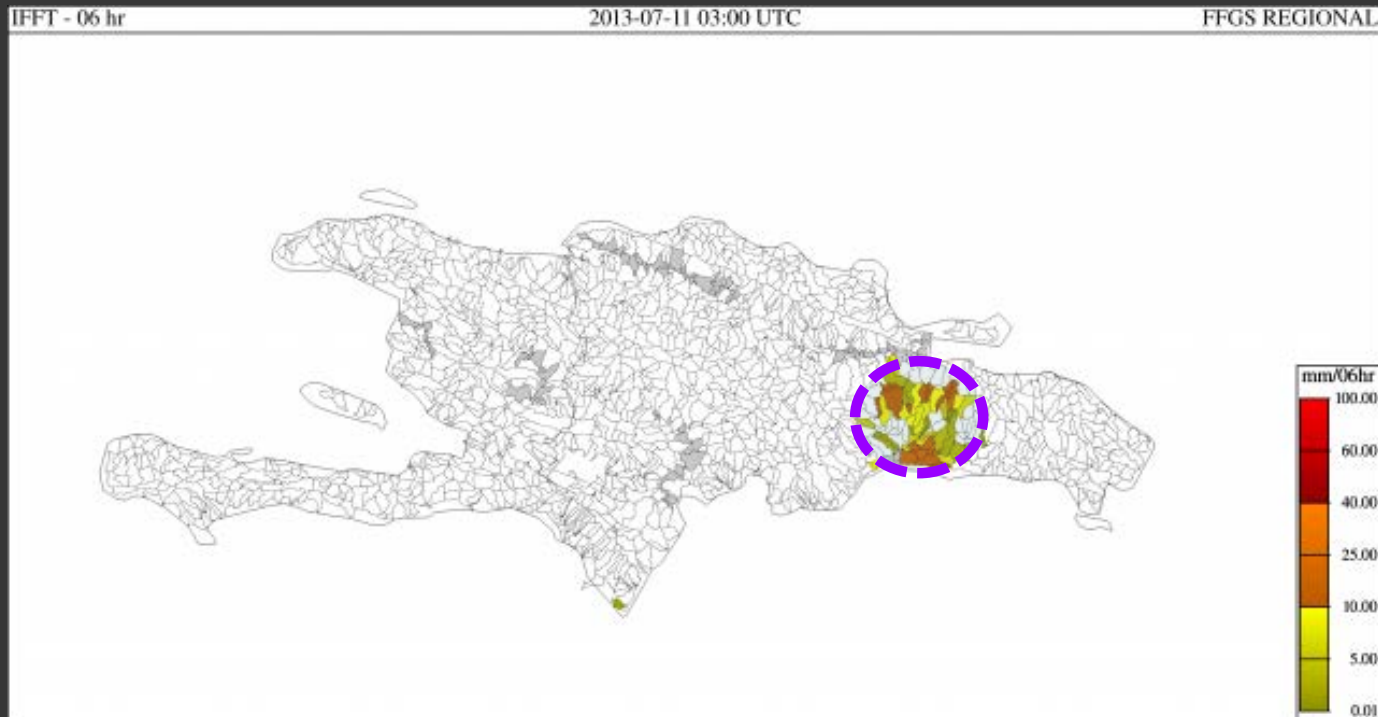


The Flash Flood Guidance (FFG) product is an index that indicates:

- the total volume of rainfall
- over a given duration and
- over a given small catchment

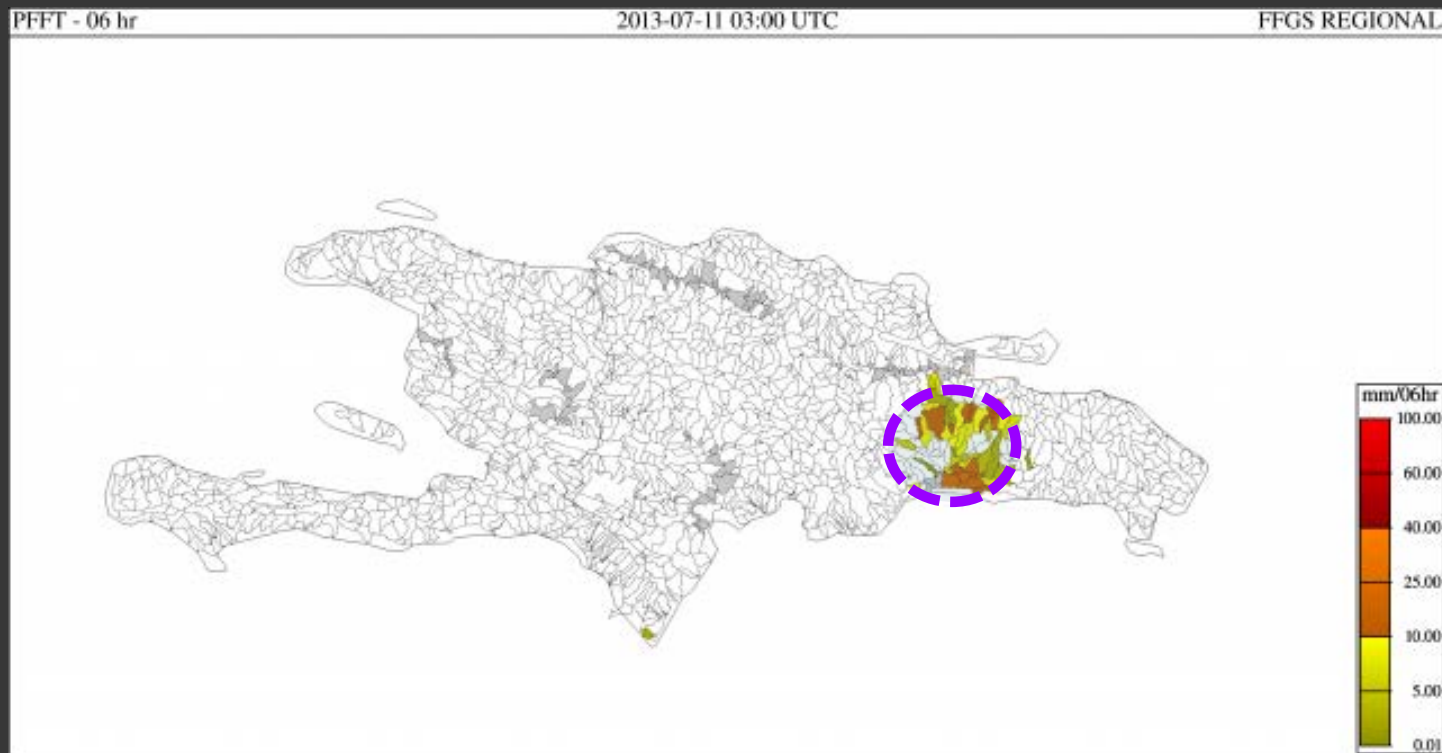
which is just enough to cause bankfull flow at the outlet of the draining stream.

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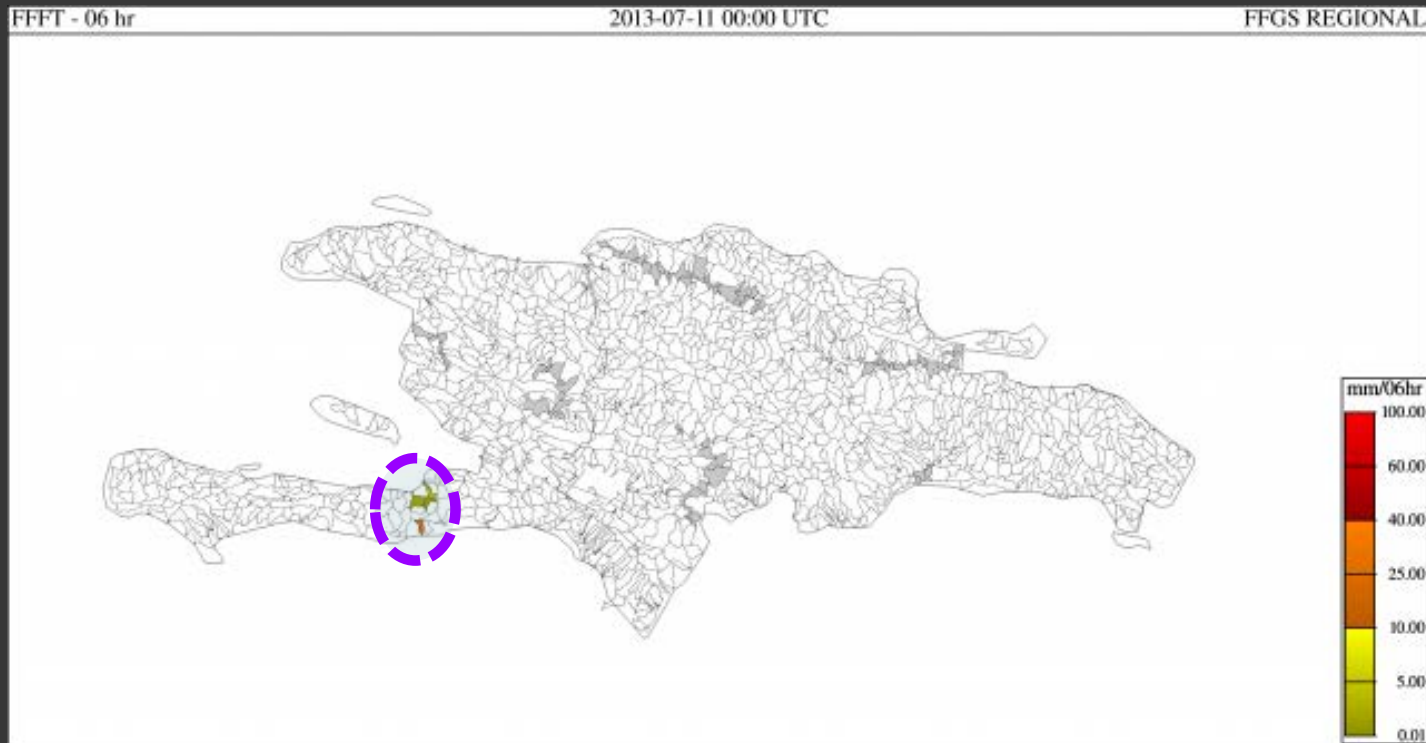
The Imminent Flash Flood Threat (IFFT) product provides the forecaster with an idea of likely regions of imminent flash flood threats.

The flash flood guidance system offers products to assist forecasters



The Persistence Flash Flood Threat (PFFT) product is a forecast of flash flood threat with persistence used as the rainfall forecast for each basin.

The flash flood guidance system offers products to assist forecasters



Forecast Flash Flood Threat (FFFT) Product provides the forecaster with an idea of regions forecasted to be of concern for flash flooding.



6. Forecasting Flash Floods

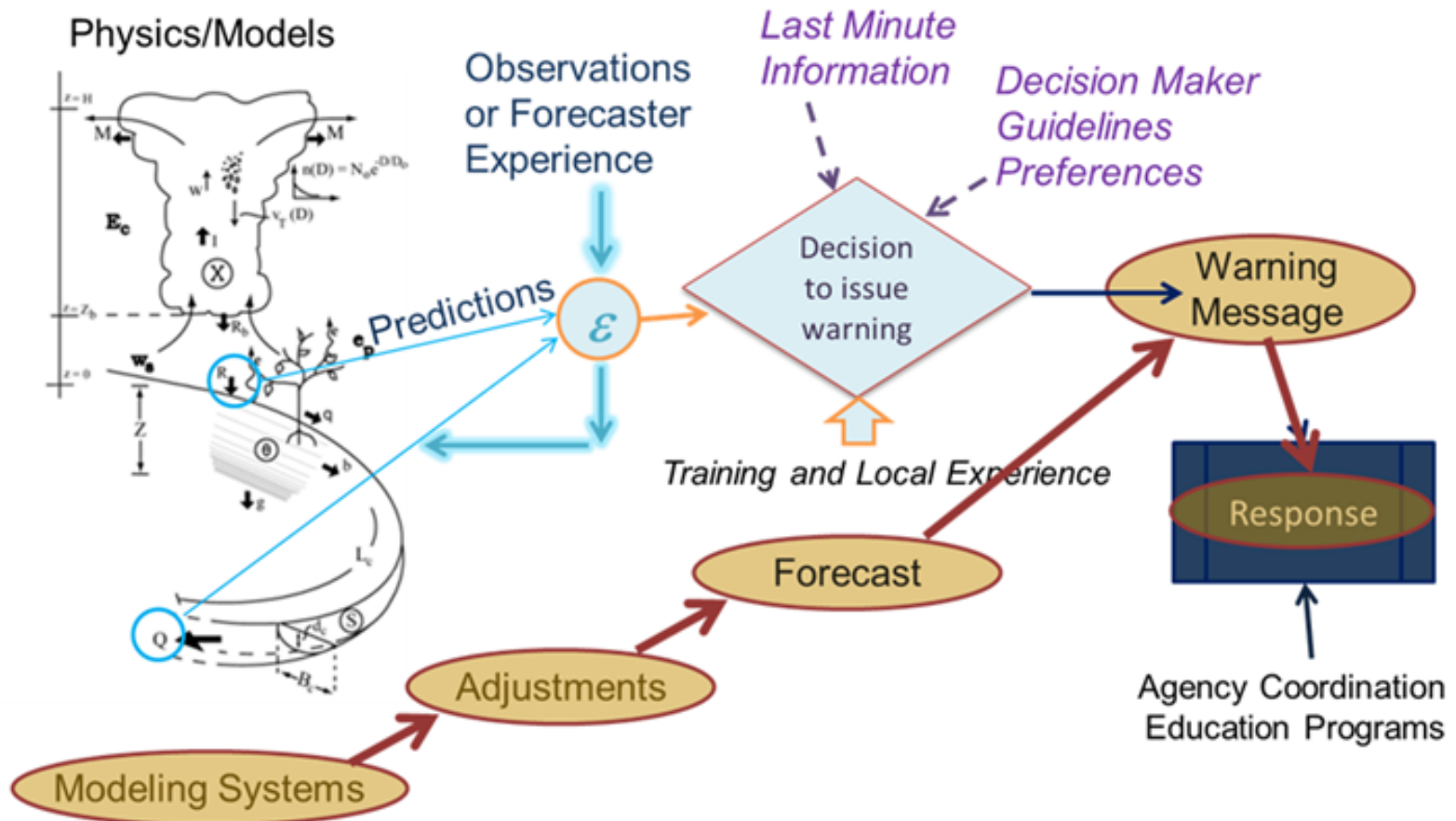
Flash Flood Forecasting

Flash floods are difficult to forecast:

- **Combination of high rainfall rate and**
 - **Rapid and efficient runoff is common to flash flood events**
-
- **Many countries warnings for flash floods: “heavy rain with potential for flash floods”**
 - **Ignore underlying hydrological conditions, so there is a need to know accurately the rainfall rate over a river basin**
 - **Compared to a river flood, a flash flood is a true hydrometeorological problem**
 - **Need for a meteorological & hydrological based flash flood forecasting system at time of flood to determine basins in danger**

The Flash Flood Guidance System is an Integrated System for Real-Time Warning

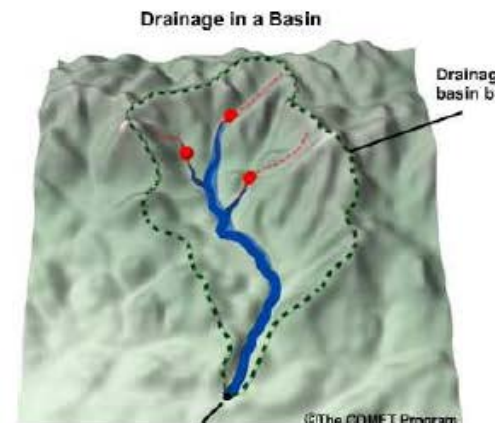
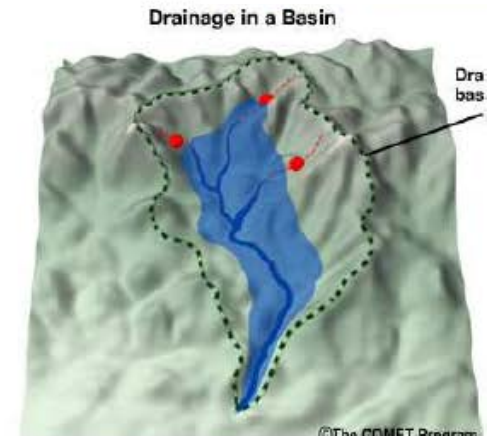
From a System of Models to a Program



GFFG Integrated Approach for Real-Time Warnings:
End-to-End Chain - Modeling-Adjustments-Forecasts-Warning-Response

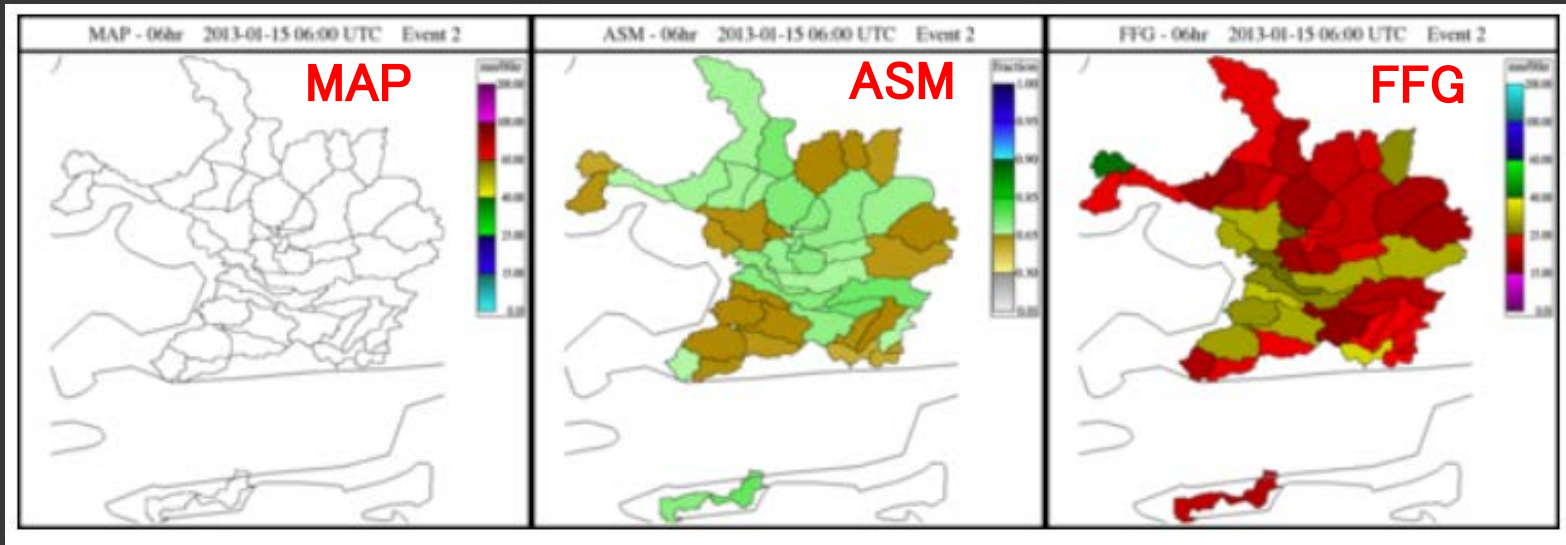
How do you predict a flash flood?

- Forecaster's question:
 - How much rain will cause a flood in this particular area?
 - What do you need to know to answer this question?
 - How much water will run off?
 - How full is the stream?
 - What about recent rain?
 - How river basin responds - Hydrology
 - How much rain am I expecting over this area?
 - Weather forecasting – Meteorology
- = Hydro-meteorological problem

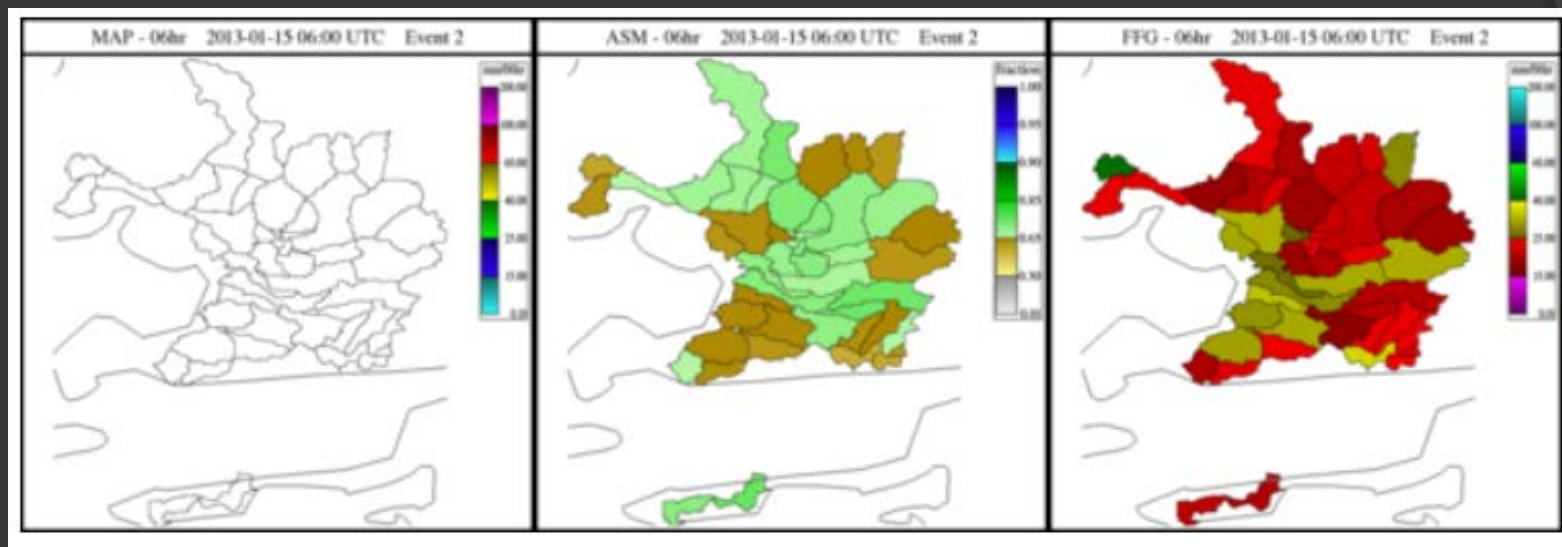


Flash Floods

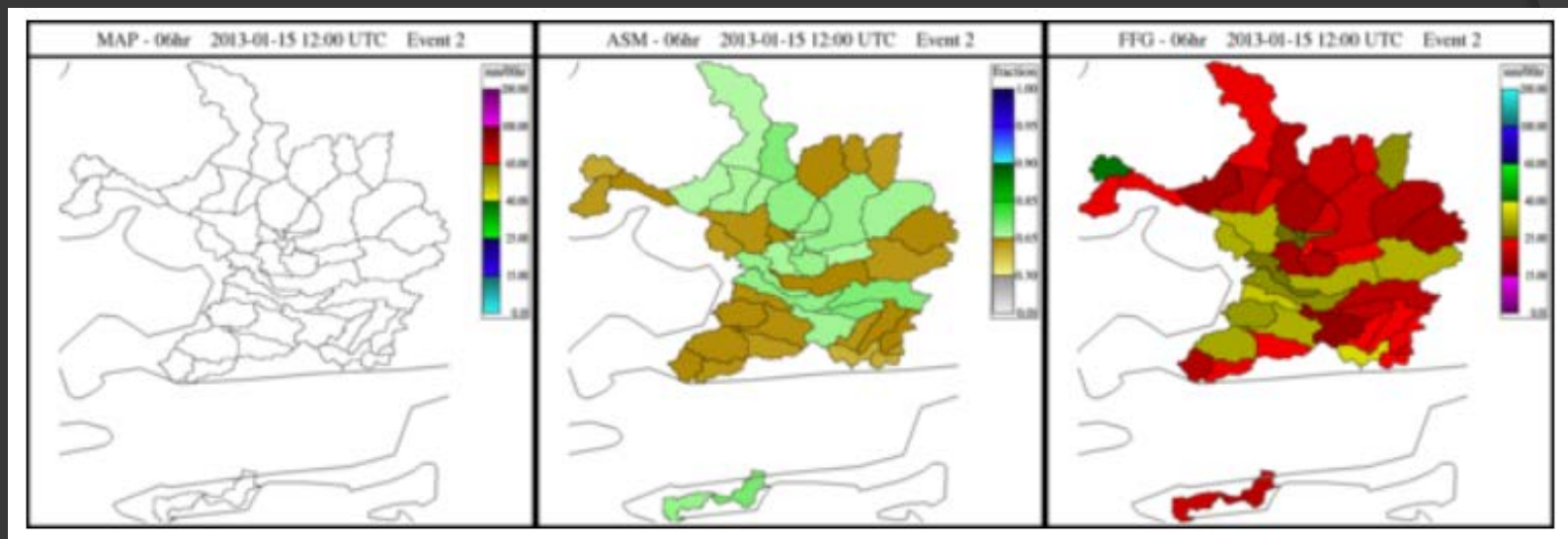
A flash flood is a rapid onset flood (<6 hours) following the causative event (heavy rain, dam failure) "*too much water, too little time*"



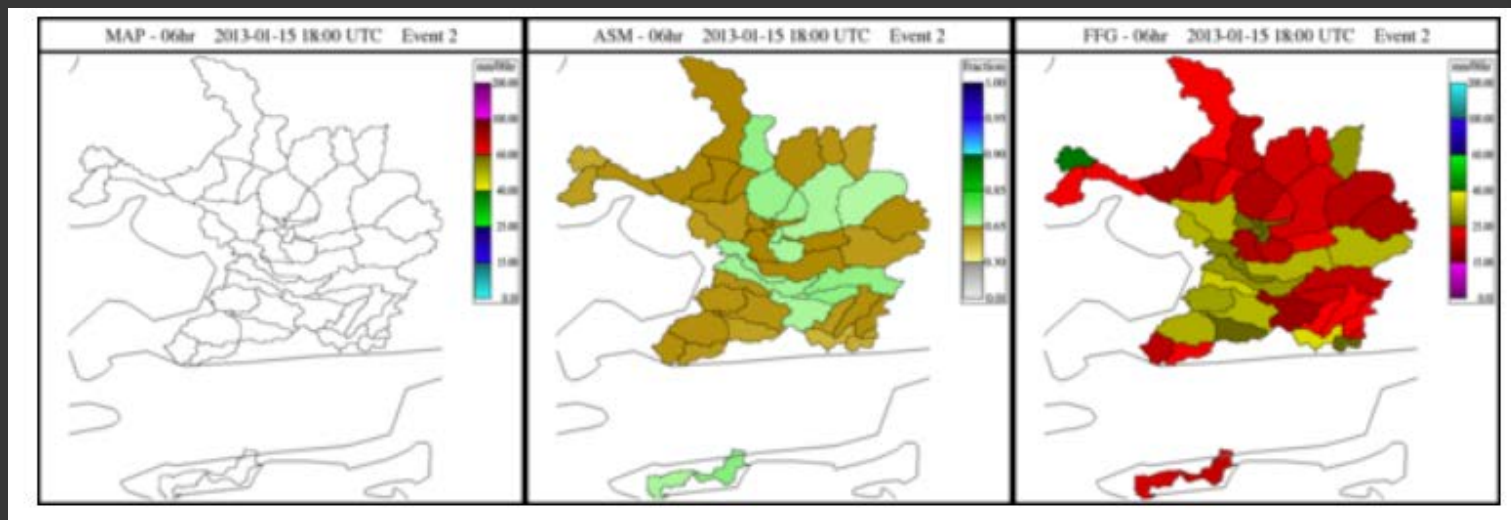
Three of the flash flood guidance system products forecasters use to forecast flash floods



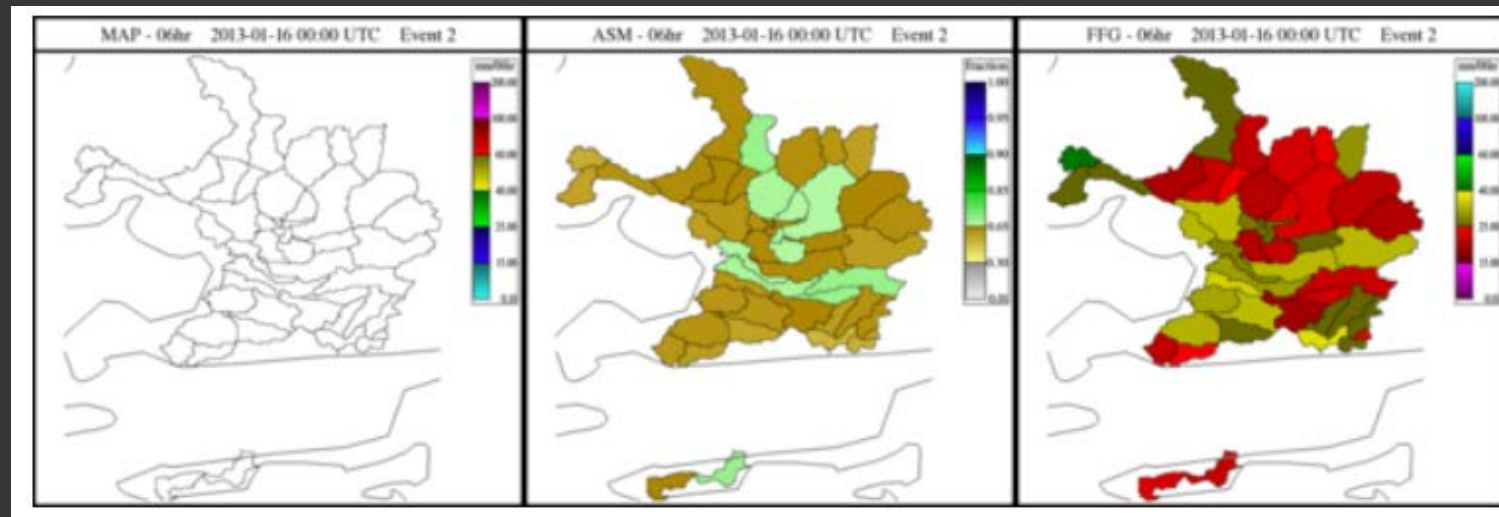
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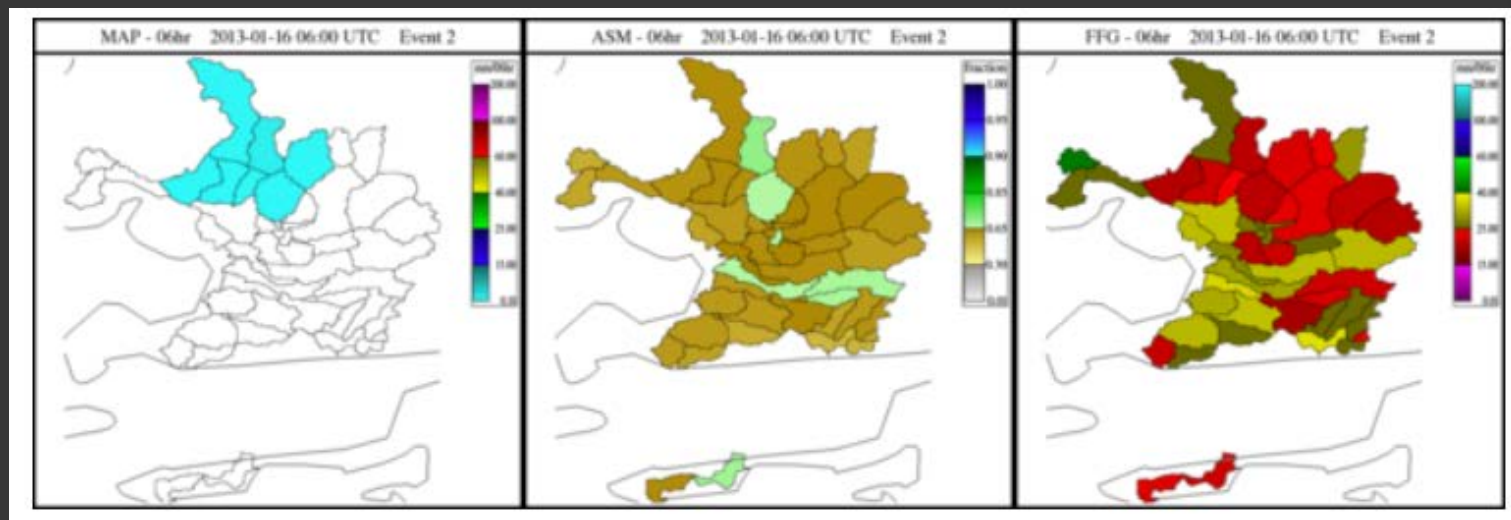
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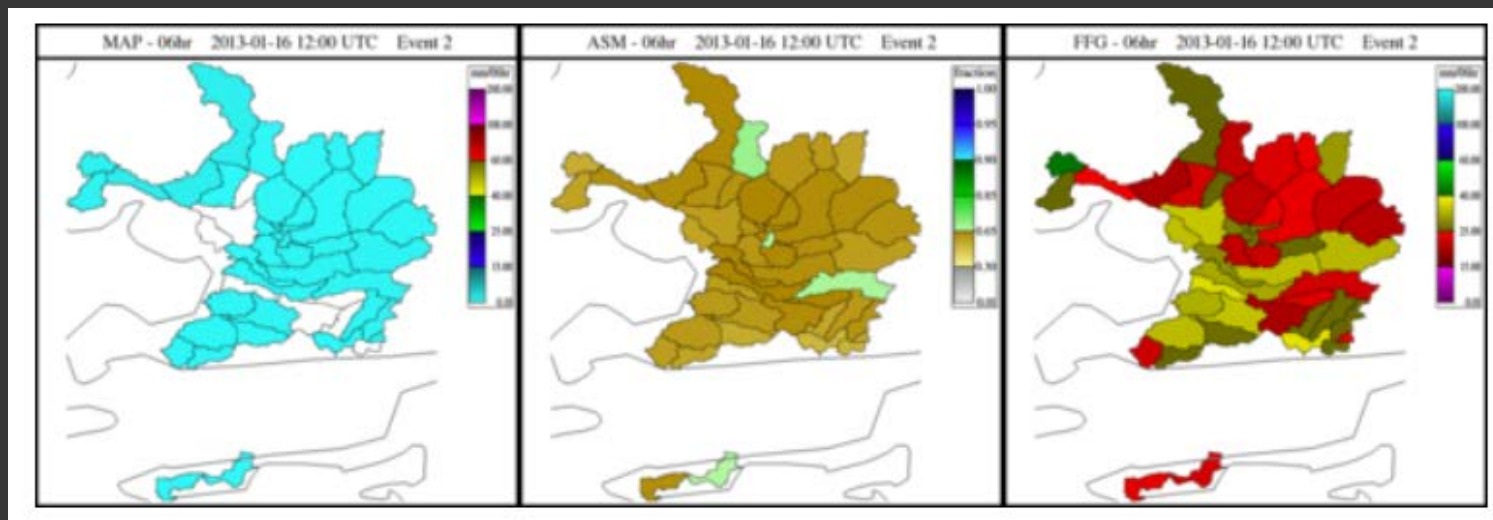
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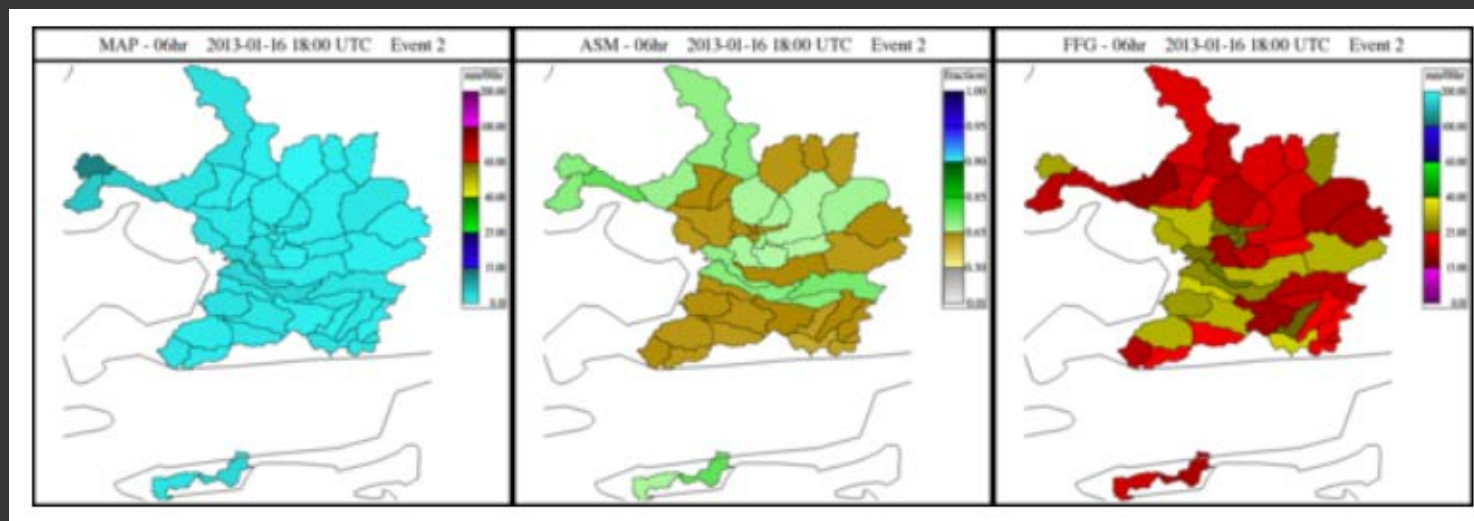
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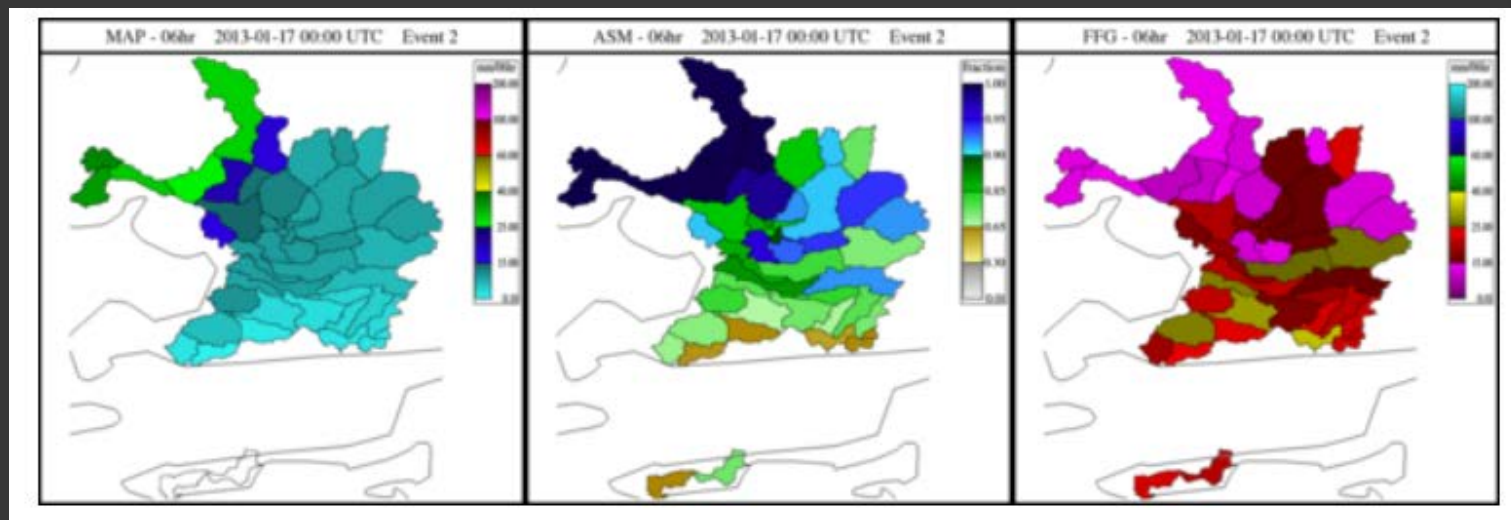
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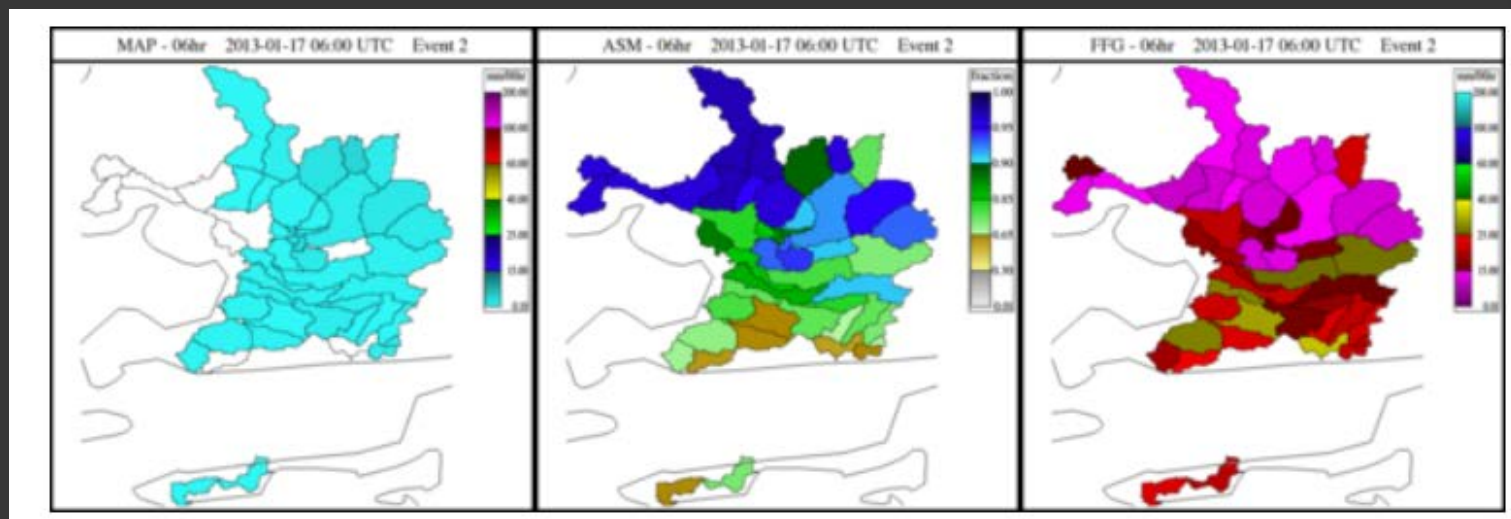
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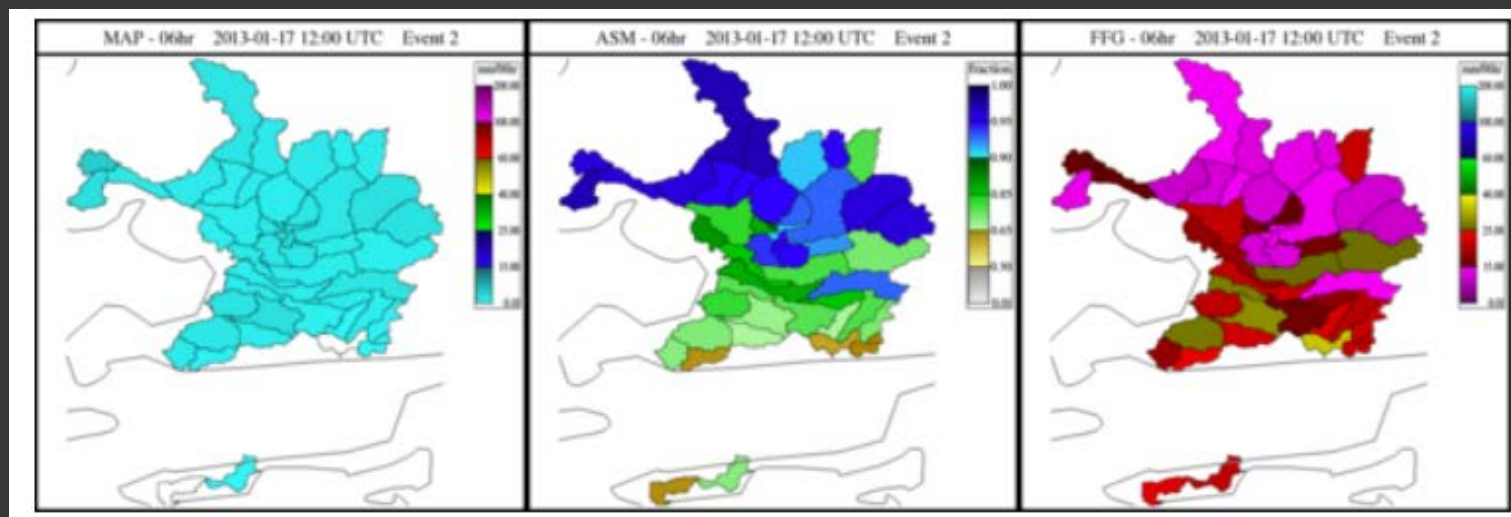
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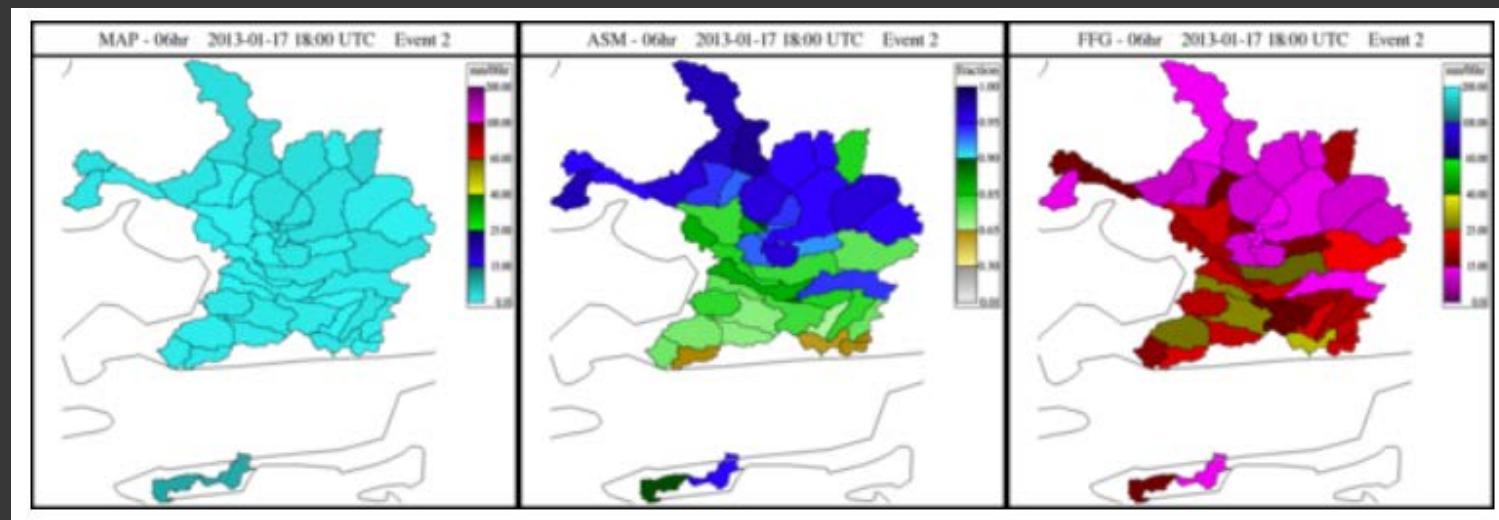
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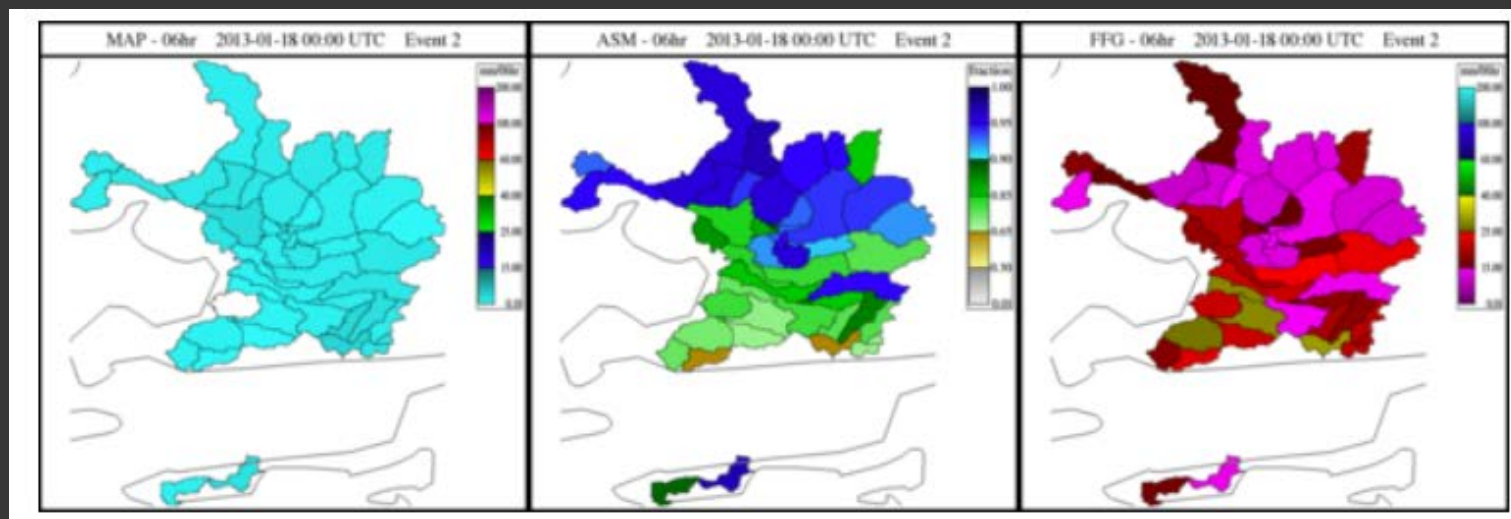
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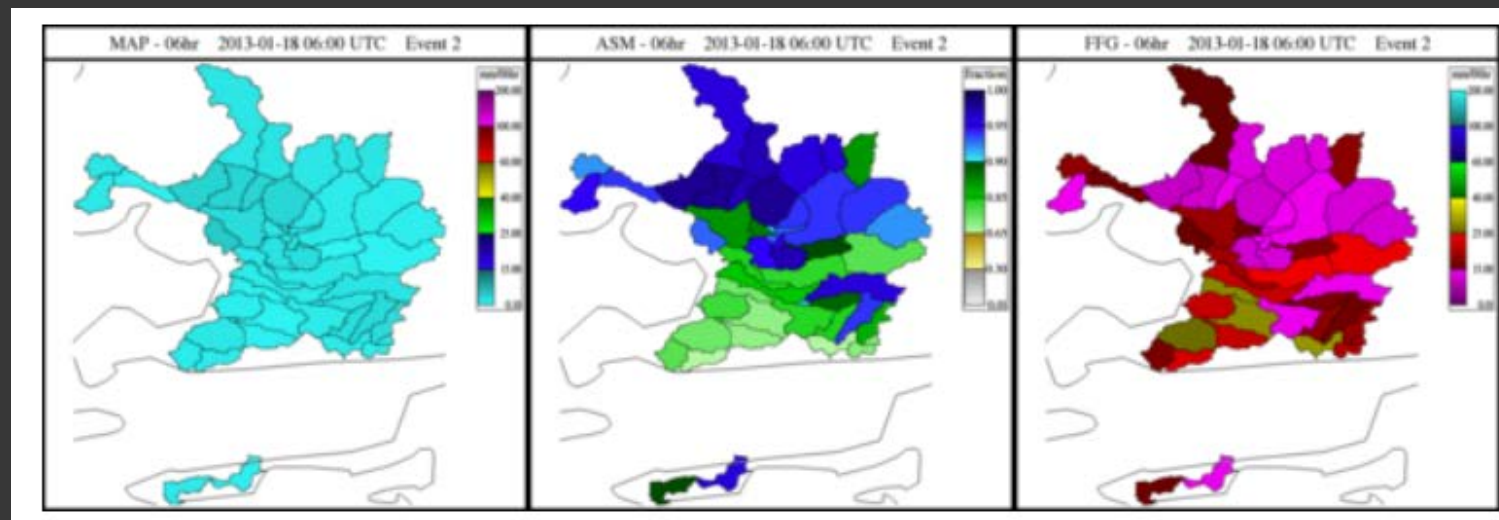
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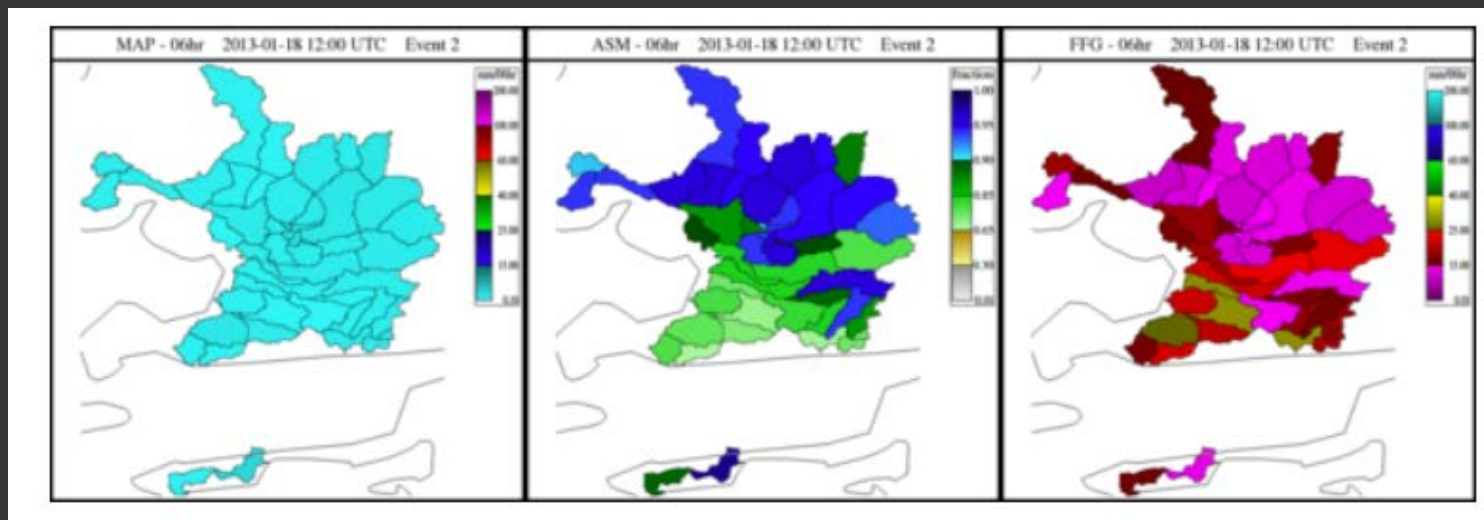
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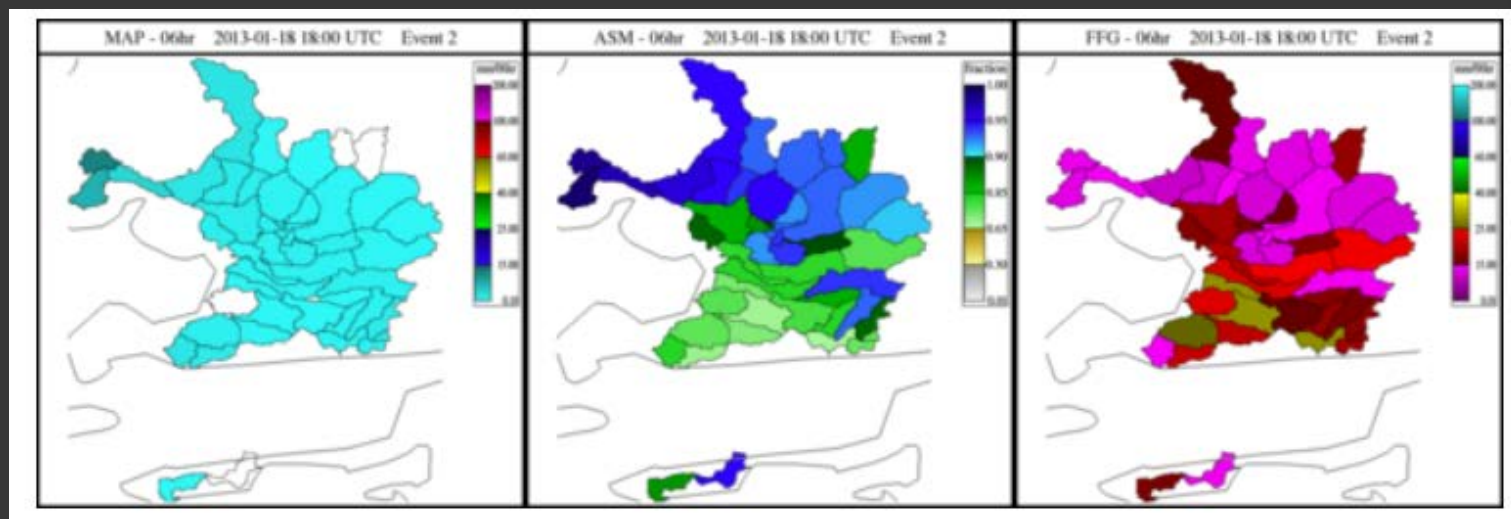
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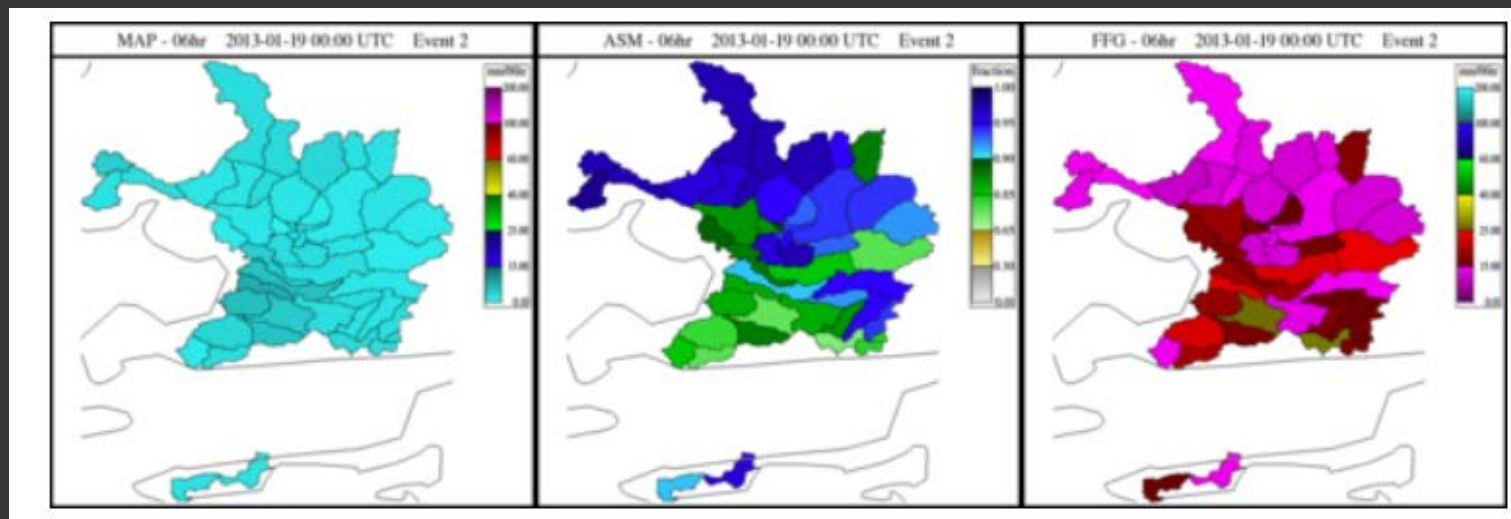
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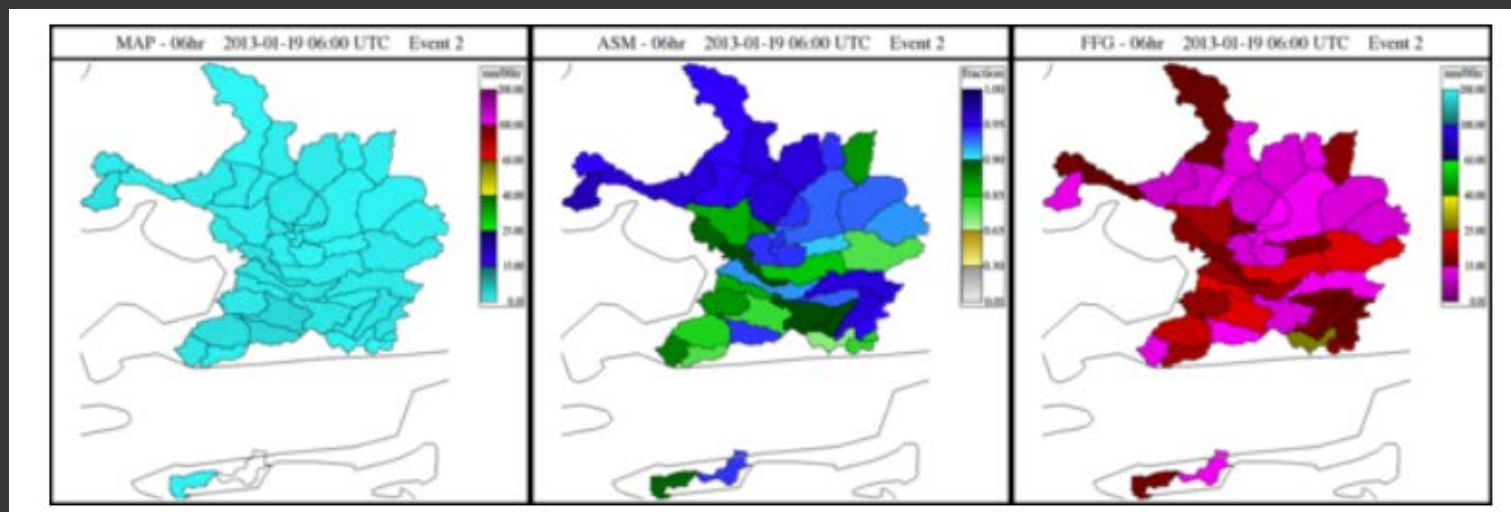
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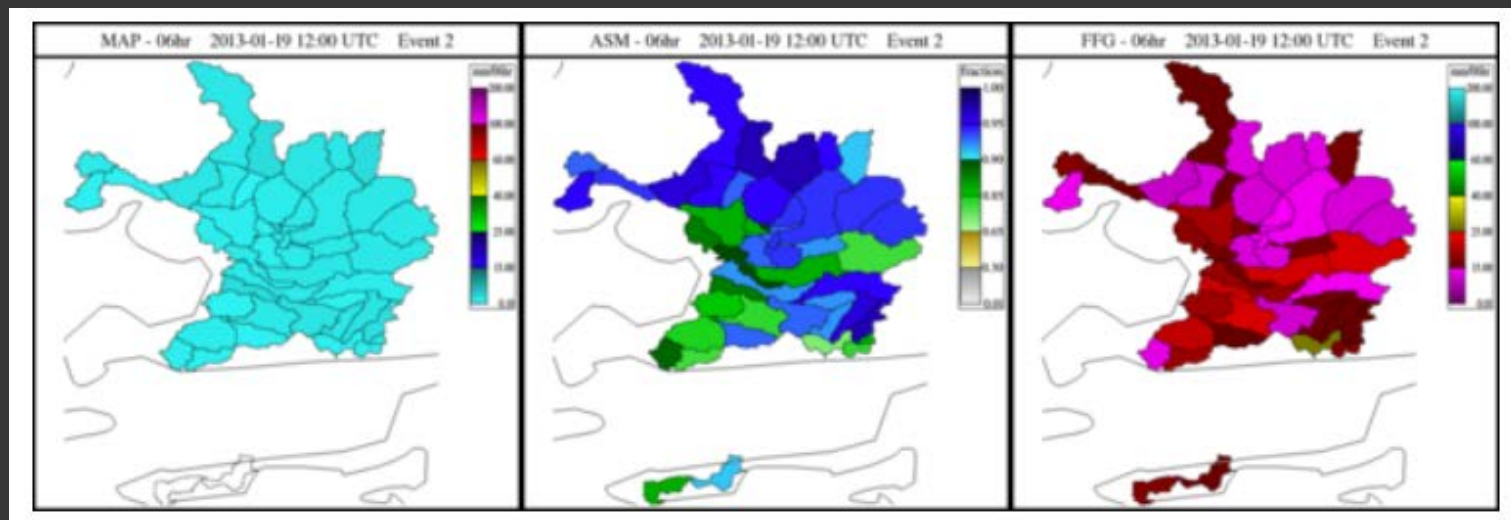
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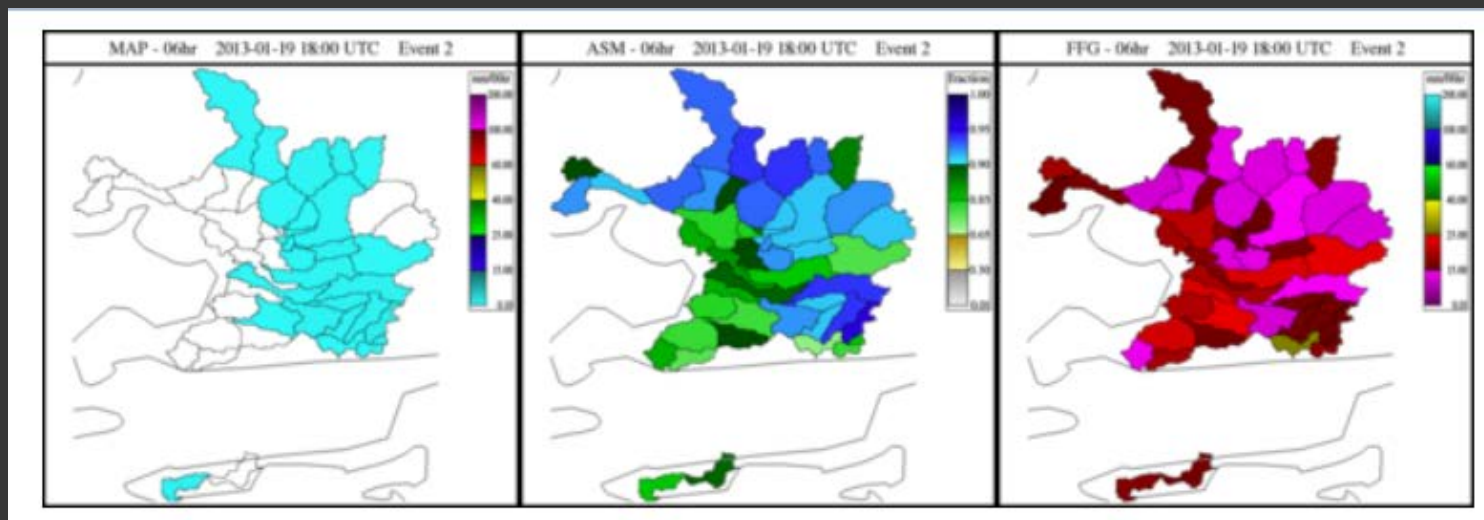
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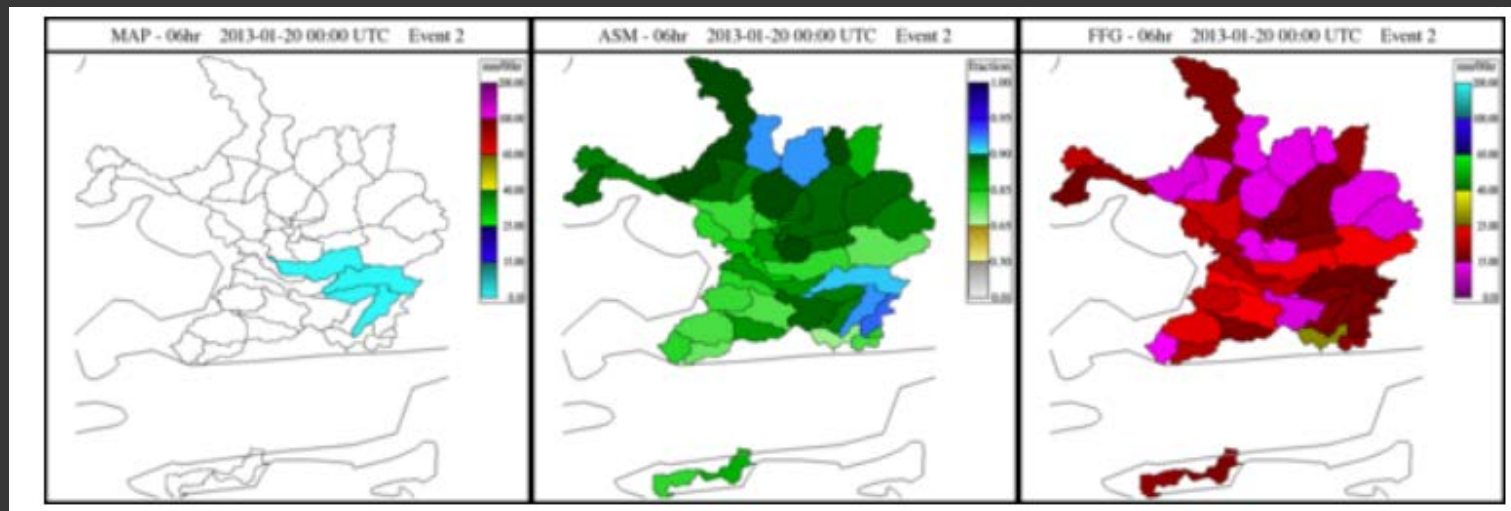
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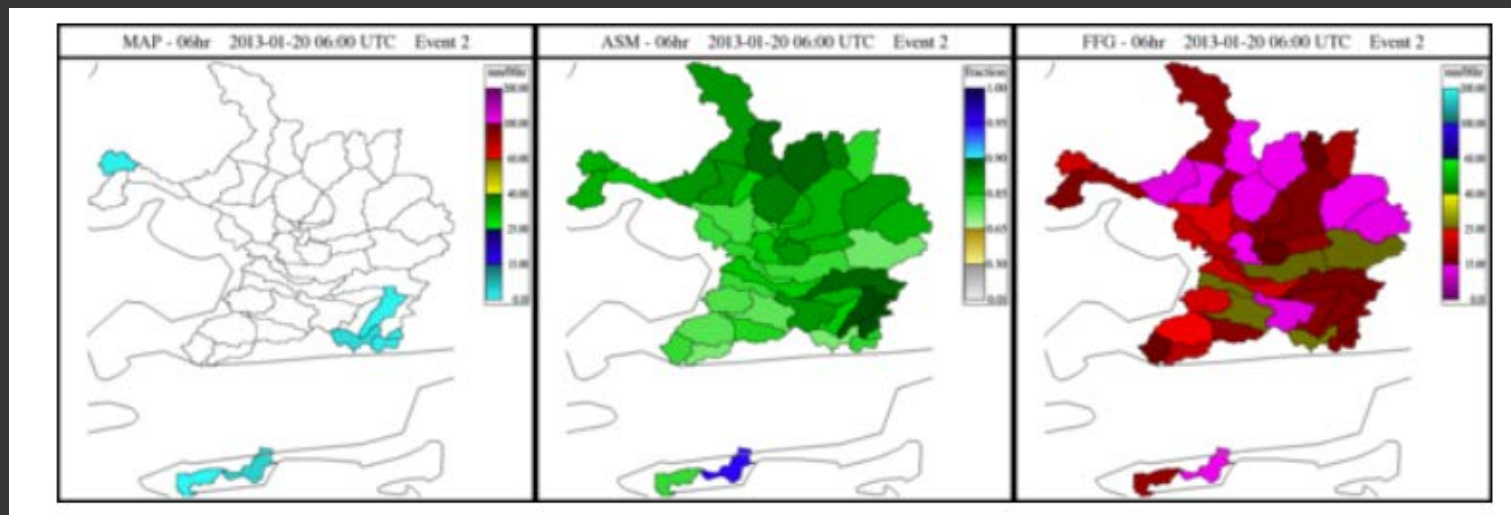
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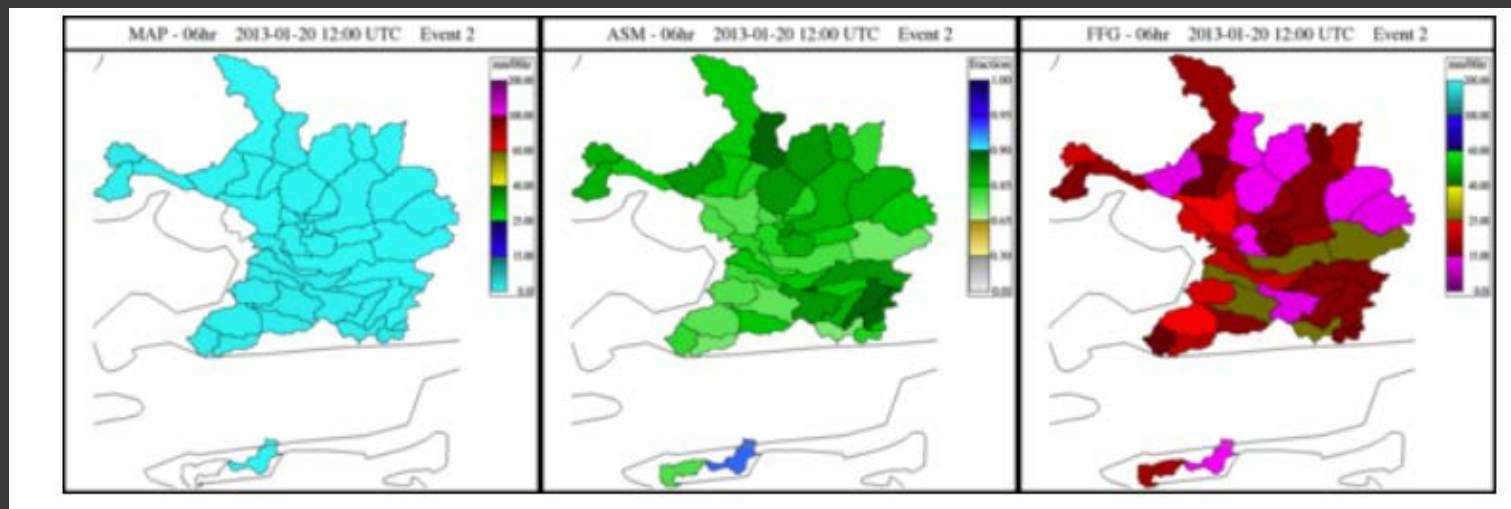
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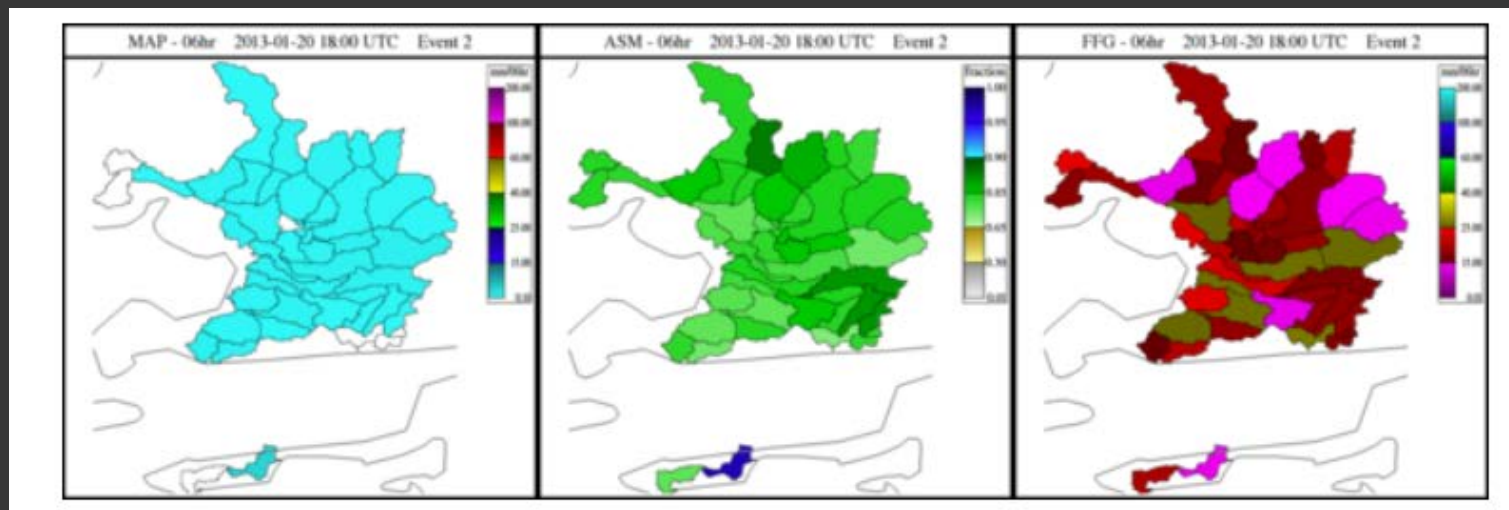


Three of the flash flood guidance system products forecasters use to forecast flash floods



Three of the flash flood guidance system products forecasters use to forecast flash floods

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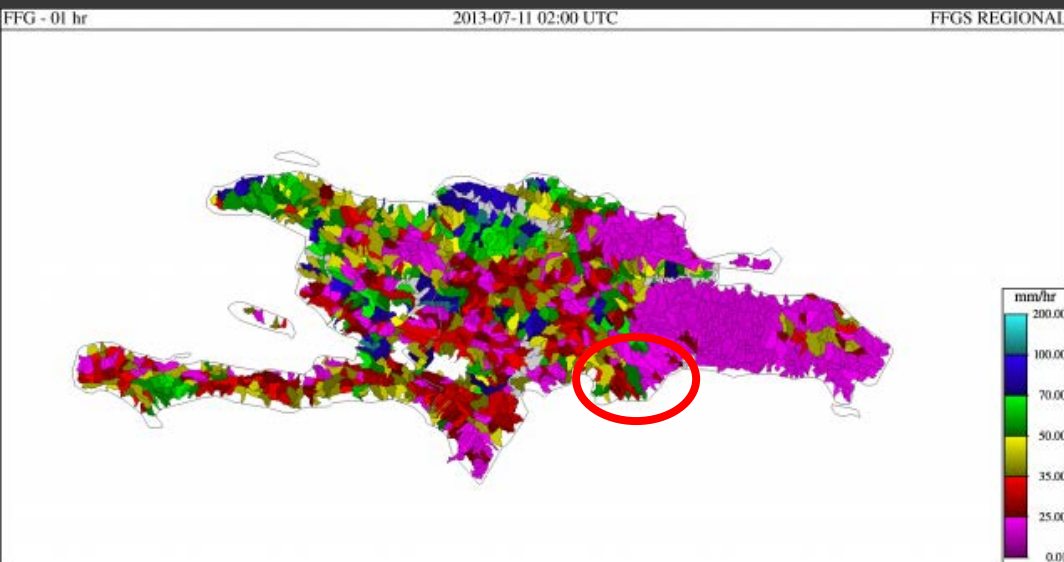
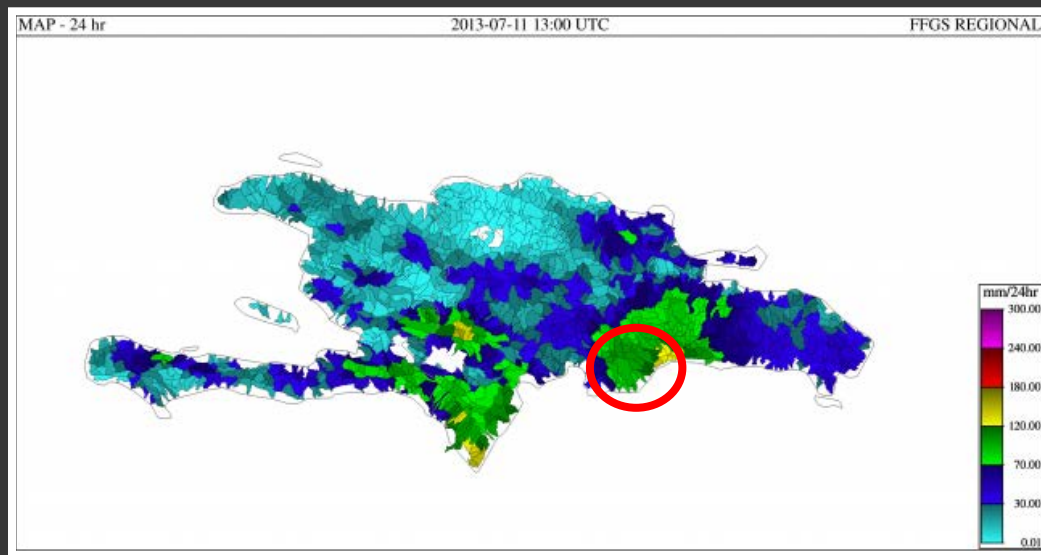
Performance of FFGS so far

HDRFFG provides useful guidance particularly for larger scale systems on potential flooding over Haiti and Dominican Republic.

- The FFGS systems in the region using satellite rainfall estimation
 - Deal well with larger scale events (TCs, MCSs)
 - Struggle with small scale high intensity events (individual T/S)

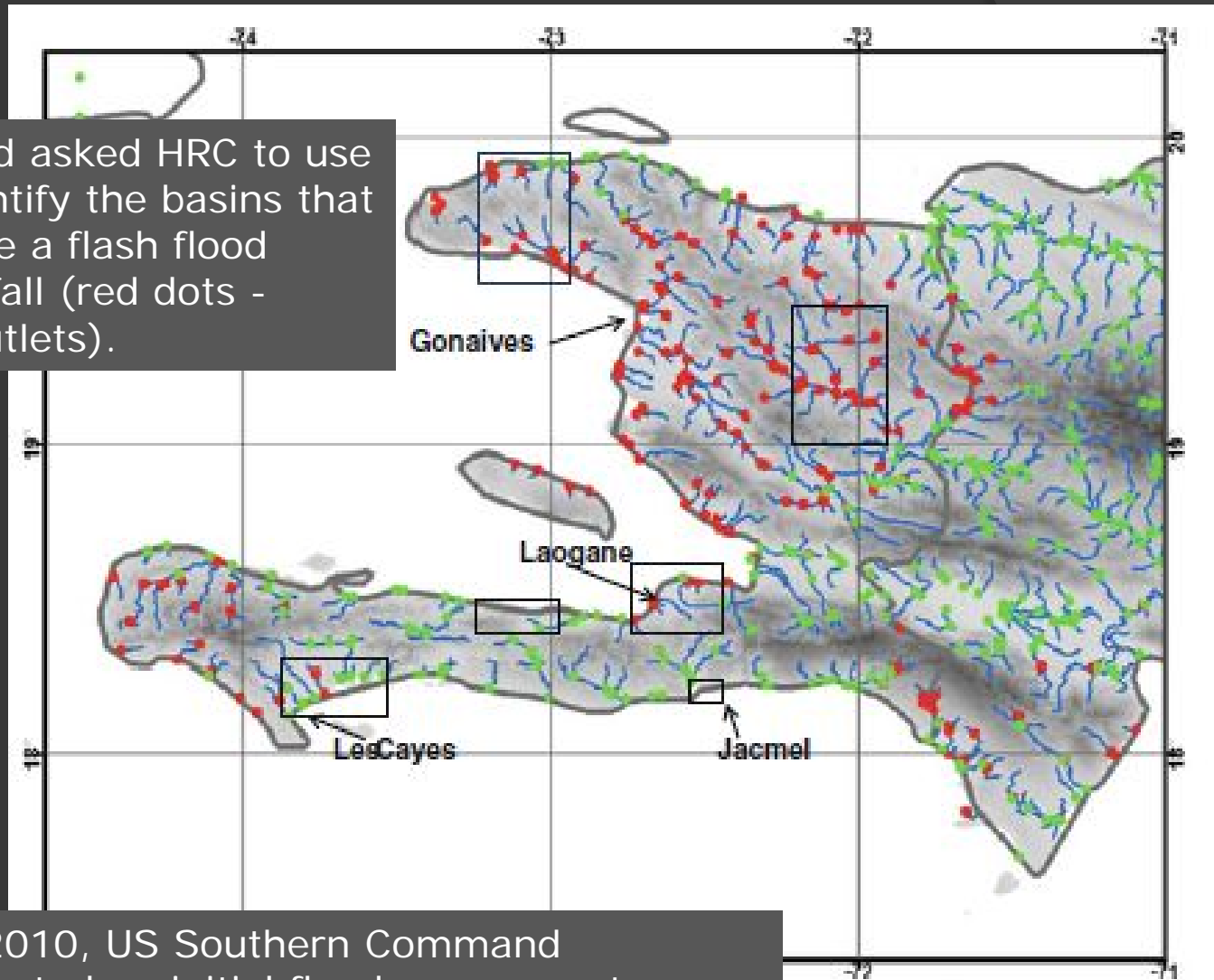
• However, HDRFFG still provide very valuable guidance to forecasters of a hazard that had no information on in the past:

- The hydrological response of small streams to rain = greater flash flood potential.



Hurricane Tomas, November 2010

US Southern Command asked HRC to use the FFG system to identify the basins that were likely to generate a flash flood based on satellite rainfall (red dots - located at the basin outlets).



On November 7th, 2010, US Southern Command (SOUTHCOM) conducted an initial flood assessment.



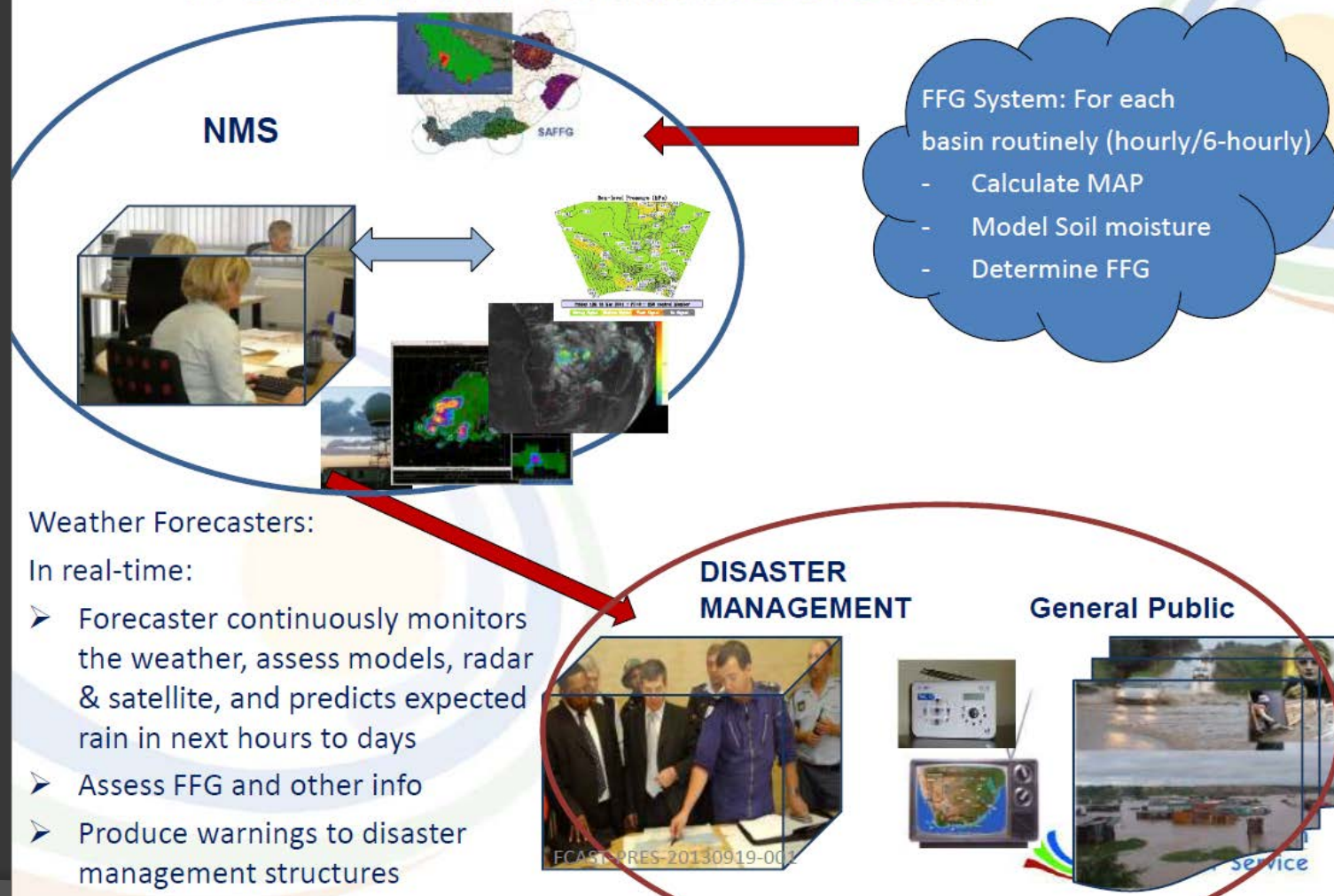
6. Conclusions

Flash flood forecasting is becoming more and more important worldwide



The flash flood guidance system supports forecasters to produce advisories, watches and warnings of the potential for flash floods to disaster management agencies.

FFGS IN EARLY WARNING SYSTEM



Challenges

- **Emphasis needs to be on enhancing institutional collaboration**
- **Stakeholders needs must be understood**
- **Routine incorporation of the HDRFFG by operational forecasters**
- **Formalized communication platform of flash flood advisories, watches and warnings with key stakeholders**

REPUBLIC OF HAITI & DOMINICAN REPUBLIC



Thank You

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