OVERVIEW OF
FLASH FLOOD GUIDANCE
SYSTEM PRODUCTS

Dr Rochelle Graham – Climate Scientist

Haiti and Dominican Republic Flash Flood
Initial Planning Meeting

September 7th to 9th, 2016
Haiti and Dominican Republic Flash Flood Guidance System

Program Partners

USAID/Office of U.S. Foreign Disaster Assistance

Hydrologic Research Center

World Meteorological Organization

National Oceanic and Atmospheric Administration/National Weather Service
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
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

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**
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,
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,
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,
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.
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.
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)
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) 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.

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

Physics/Models

Observations or Forecaster Experience

Decision to issue warning

Decision Maker Guidelines Preferences

Last Minute Information

Warning Message

Training and Local Experience

Forecast

Response


Adjustments

Modeling Systems
# HDRFFG - Haiti and Dominican Republic Flash Flood Guidance System

**Date du Jour:** 2015-06-16 23:56 UTC  
**Date de navigation:** 2015-06-16 23:00 UTC

<table>
<thead>
<tr>
<th>DT</th>
<th>Satellite</th>
<th>MAP Fusionnée</th>
<th>ASM</th>
<th>FFG</th>
<th>IFFT</th>
<th>PFFT</th>
<th>Prévision</th>
<th>FMAP</th>
<th>FFTT</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-hr</td>
<td><img src="image" alt="Satellite" /></td>
<td><img src="image" alt="MAP Fusionnée" /></td>
<td><img src="image" alt="ASM" /></td>
<td><img src="image" alt="FFG" /></td>
<td><img src="image" alt="IFFT" /></td>
<td><img src="image" alt="PFFT" /></td>
<td><img src="image" alt="Prévision" /></td>
<td><img src="image" alt="FMAP" /></td>
<td><img src="image" alt="FFTT" /></td>
</tr>
<tr>
<td>03-hr</td>
<td><img src="image" alt="Satellite" /></td>
<td><img src="image" alt="MAP Fusionnée" /></td>
<td><img src="image" alt="ASM" /></td>
<td><img src="image" alt="FFG" /></td>
<td><img src="image" alt="IFFT" /></td>
<td><img src="image" alt="PFFT" /></td>
<td><img src="image" alt="Prévision" /></td>
<td><img src="image" alt="FMAP" /></td>
<td><img src="image" alt="FFTT" /></td>
</tr>
<tr>
<td>06-hr</td>
<td><img src="image" alt="Satellite" /></td>
<td><img src="image" alt="MAP Fusionnée" /></td>
<td><img src="image" alt="ASM" /></td>
<td><img src="image" alt="FFG" /></td>
<td><img src="image" alt="IFFT" /></td>
<td><img src="image" alt="PFFT" /></td>
<td><img src="image" alt="Prévision" /></td>
<td><img src="image" alt="FMAP" /></td>
<td><img src="image" alt="FFTT" /></td>
</tr>
<tr>
<td>24-hr</td>
<td><img src="image" alt="Satellite" /></td>
<td><img src="image" alt="MAP Fusionnée" /></td>
<td><img src="image" alt="ASM" /></td>
<td><img src="image" alt="FFG" /></td>
<td><img src="image" alt="IFFT" /></td>
<td><img src="image" alt="PFFT" /></td>
<td><img src="image" alt="Prévision" /></td>
<td><img src="image" alt="FMAP" /></td>
<td><img src="image" alt="FFTT" /></td>
</tr>
</tbody>
</table>

Produit Composite... text: DBF  
Transfert de données par SFTP (requiert le client SFTP): [EXPORTS/REGIONAL/2015-06-16](image)

| Totaux cumulatifs des observations pluviométriques Surfnet se terminant le 2015-06-16 23:00 UTC |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Identifier de la station | Nom de la Station | Date de l'observation | Précipitation (mm) | Température (°C) | Humidité Relative (%) | Pression Atmosphérique (mb) | Radiations Solar | Direction du Vent | Vitesse du Vent | Batterie Voltage |
| Warnings | Warnings | Warnings | Warnings | Warnings | Warnings | Warnings | Warnings | Warnings | Warnings | Warnings |
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
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
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
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
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
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.
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.
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
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
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
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
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
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.
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).

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**

- **Weather Forecasters:**
  - In real-time:
    - Forecaster continuously monitors the weather, assess models, radar & satellite, and predicts expected rain in next hours to days
    - Assess FFG and other info
    - Produce warnings to disaster management structures

- **FFG System:** For each basin routinely (hourly/6-hourly)
  - Calculate MAP
  - Model Soil moisture
  - Determine FFG

**DISASTER MANAGEMENT**

**General Public**

**NMS**
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
Thank You