The FFGS Approach to Flash Flood Forecasting and Warning

HYDROLOGIC RESEARCH CENTER

5 October 2016
What do we Call Flash Floods?

**WORLD METEOROLOGICAL ORGANIZATION (WMO):**

“ A flood of short duration with a relatively high peak discharge ”

**AMERICAN METEOROLOGICAL SOCIETY (AMS):**

“ A flood that rises and falls quite rapidly with little or no advance warning, usually the result of intense rainfall over a relatively small area ”

A local hydrometeorological phenomenon that requires:
1. BOTH Hydrological and Meteorological expertise for real time forecasting/warning
2. Knowledge of local up to the hour information for effective warning

*Usually, flow crest is reached within 6 hours of causative event (Only consider < 2000 km^2)*
Natural Causes of Flash Floods

- Intense rainfall from *slow moving* thunderstorms or tropical systems
- Orographic rainfall in *steep* terrain
- Soil *saturation or impervious* land surfaces
- Hydraulic *channel* properties
- Sudden release of impounded water (natural dam or human-made dam)
The Need

**Flash Floods** are very significant disasters globally ...

- Highest number of deaths per people affected

... **BUT** there are no discernible trends for loss reduction

- 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
## Large River Flooding vs Flash Flooding

<table>
<thead>
<tr>
<th>LRF</th>
<th>FF</th>
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<tbody>
<tr>
<td>➢ <em>Catchment response affords long lead times</em></td>
<td>➢ <em>Catchment response is very fast and allows very short lead times (&lt;12hrs)</em></td>
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<tr>
<td>➢ <em>Entire hydrographs can be produced w/ low uncertainty with good quality data</em></td>
<td>➢ <em>Prediction of occurrence is of interest</em></td>
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<td>➢ <em>Local information less valuable</em></td>
<td>➢ <em>Local information is very valuable</em></td>
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<tr>
<td>➢ <em>A hydrologic forecasting problem primarily</em></td>
<td>➢ <em>A truly hydro-meteorological forecasting problem</em></td>
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<tr>
<td>➢ <em>Affords time for coordination of flood response and damage mitigation</em></td>
<td>➢ <em>Coordination of forecasting and response is challenging over short times (Careful Planning Needed)</em></td>
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Operational Approaches for Flash Flood Warning

1. Site Specific (data rich catchments with special forecast interests)
2. Area-wide modeling with remotely sensed data and global datasets
   2a. Flash Flood Guidance (data sparse regions for public watches and warnings of flash flood occurrence)
   2b. Full Distributed Hydrograph Modeling (in regions with good data when entire hydrographs are needed) (High Uncertainty on smaller scales)
What are processes for the production of surface runoff and flash flooding?

- **SATURATION FROM BELOW** – ALL RAIN INFILTRATES (DOMINANT FOR MOST SOILS)
- **INFILTRATION CONTROLLED** – RAIN RATES IN EXCESS OF INFILTRATION CAPACITY PRODUCE RUNOFF (CALY SOILS)
- **COMBINED** – HETEROGENEOUS AREAS AND PROFILES
Examples of soil texture and infiltration rates


FFG Fundamental Concepts

Rainfall threshold (familiar concept)

Meteorology and hydrology decoupled for adjustments

Concerned only with bankfull flow

Soil Water Deficit
Channel bankfull storage

FFG: Amount of **rainfall** of a given duration and over a given catchment that is just enough to cause **flooding conditions** at the **outlet of the draining stream**

Threshold exceedance concept to estimate occurrence only!

Urban environment
- Not represented due to scale
- Not represented due to sewers

Location of Occurrence
The Global Initiative for Flash Floods

The Hydrologic Research Center (HRC) has signed a joint Memorandum of Understanding to implement regional flash flood guidance systems worldwide with:

*the United Nations – World Meteorological Organization (WMO)*

*the U.S. Agency for International Development/Office of U.S. Foreign Disaster Assistance (USAID/OFDA)*

*and the U.S. National Oceanic and Atmospheric Administration (NOAA).*

Integrated Systems for Real-Time Warning

Observations or Forecaster Experience

Last-Minute Information

Decision to issue warning

Warning Message

Response

Decision Maker Guidelines and Preferences

Training and Local Experience

Agency-Coordination Education Programs

Modeling Systems

Predictions

Forecast

Adjustments

Viewpoint

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FLASH FLOOD GUIDANCE SYSTEM
From Global Data and Regional Hydrometeorology to Country Data and Warnings

Decisions are made with multiple datasets and under uncertainty.

There is a need to modify the products of the regional system by country forecasters and have capability for estimating consequences to local flash flood potential.
Local System for Warnings

Regional Dissemination System

Database

GIS Analysis Tools

Forecaster

Country Warning Dissemination System

Regional Networks

Country Networks
Flash Flood Guidance (FFG): The amount of actual rainfall of a given duration over a small basin required to generate flooding flows at the outlet of the basin.
Rainfall Data Processing
- Quality Control
- Merging
- Bias Adjustment

Real-time Precipitation Inputs
- Satellite Rainfall Radar (as available)
- Gauge (as available)

Snow Cover
- Snow Model

Temperature
- Spatial GIS Data Analyses
- Basin Delineation Parameter Estimation (Terrain, LULC, soils, streams)
- Evapotranspiration (Climatological)

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Global Flash Flood Guidance Products

**DIAGNOSTIC**

**Flash Flood Guidance** — volume of rainfall of a given duration (1-6 hours) over a given small catchment that is just enough to cause bankfull flow at the outlet.

**PROGNOSTIC**

**Flash Flood Threat** — rainfall of a given duration in excess of the corresponding Flash Flood Guidance value (existing/past or “forecast” rainfall).

![Flash Flood Guidance Map](image1)

![Flash Flood Threat Map](image2)
Desired Prerequisites

Country data support (e.g., spatial data for soil type and texture, basin delineation verification, historical hydrometeorological data for bias adjustment and snow/soil water model calibration, etc.)

Links of regional center to national real time databases for reduction of uncertainty in precipitation input and increase of reliability

Development of databases of observed flash flood occurrence for validation

Reciprocal training of forecasters and disaster managers and development of well defined a priori plans for response

Enhance public information on flash floods, their perils and the needed response measures
Climate Change Impacts (Southern California)

Comparison of Flash Flood Occurrence, FFSM Model

21st Century Frequency, #/wet season vs. 20th Century Frequency, #/wet season
FFG Development Team at HRC

Kosta Georgakakos – Technical Director/Hydrometeorology

Robert Jubach - Program Management/Disaster Risk Reduction

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Eylon Shamir – Soil Water and Snow Models

Cris Spencer – IT Engineering/Programming

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Rochelle Graham – Education and Training