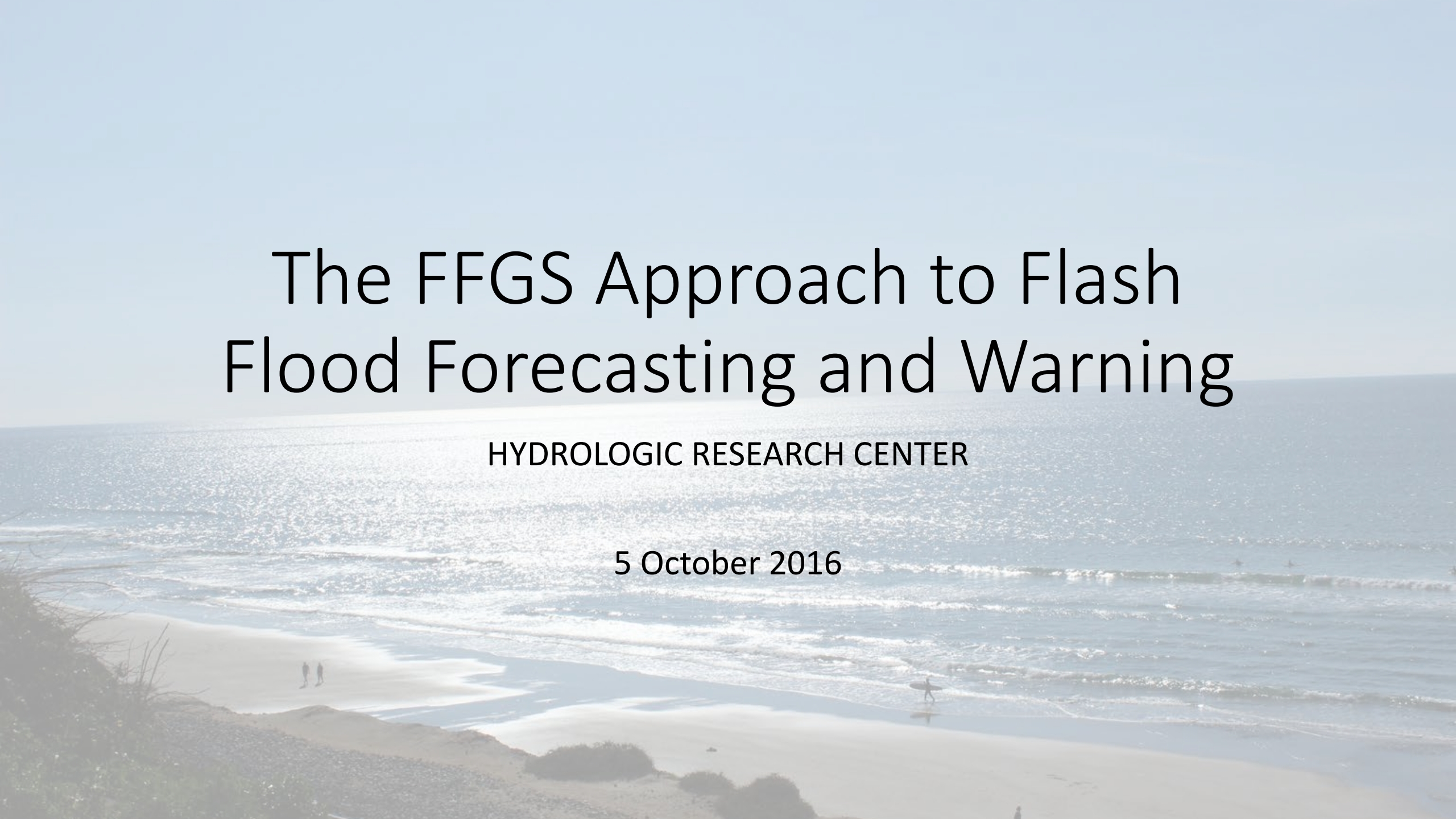


The FFGS Approach to Flash Flood Forecasting and Warning

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 **< 2000km^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

LRF

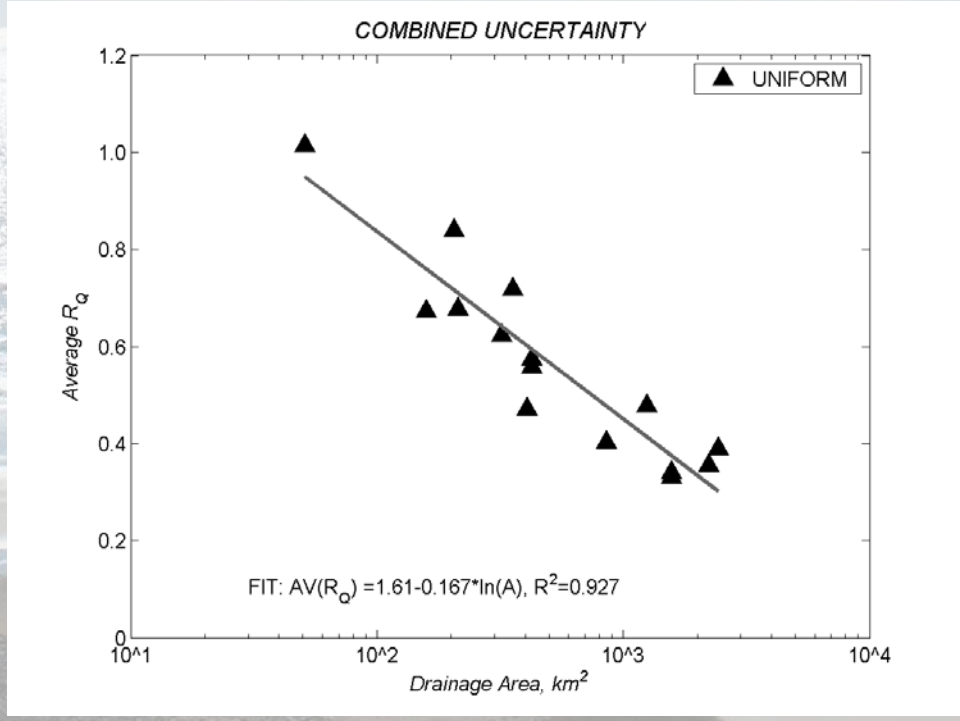
- ***Catchment response affords long lead times***
- ***Entire hydrographs can be produced w/ low uncertainty with good quality data***
- ***Local information less valuable***
- ***A hydrologic forecasting problem primarily***
- ***Affords time for coordination of flood response and damage mitigation***

FF

- ***Catchment response is very fast and allows very short lead times (< 12hrs)***
- ***Prediction of occurrence is of interest***
- ***Local information is very valuable***
- ***A truly hydro-meteorological forecasting problem***
- ***Coordination of forecasting and response is challenging over short times (Careful Planning Needed)***

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)



5 BASINS
3 LOCATIONS/BASIN
27 EVENTS/LOCATION

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

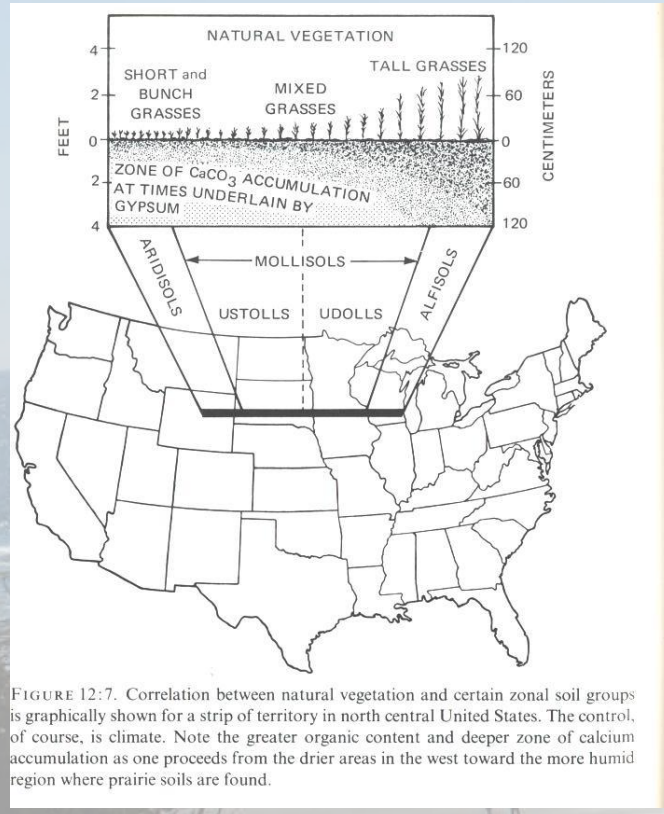


FIGURE 12:7. Correlation between natural vegetation and certain zonal soil groups is graphically shown for a strip of territory in north central United States. The control, of course, is climate. Note the greater organic content and deeper zone of calcium accumulation as one proceeds from the drier areas in the west toward the more humid region where prairie soils are found.

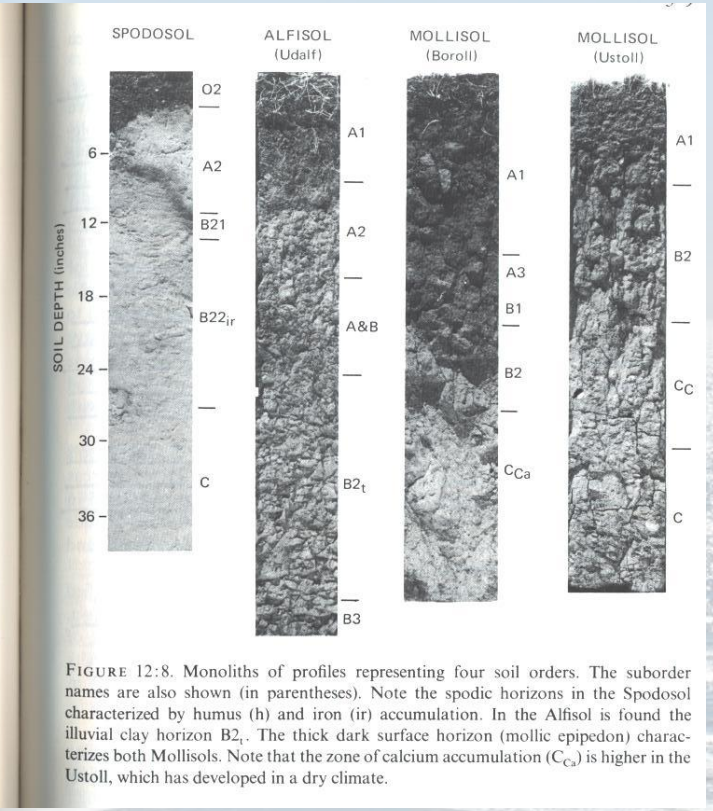


FIGURE 12:8. Monoliths of profiles representing four soil orders. The suborder names are also shown (in parentheses). Note the spodic horizons in the Spodosol characterized by humus (h) and iron (ir) accumulation. In the Alfisol is found the illuvial clay horizon $B2_t$. The thick dark surface horizon (mollic epipedon) characterizes both Mollisols. Note that the zone of calcium accumulation (C_{Ca}) is higher in the Ustoll, which has developed in a dry climate.

Brady, N.C., 1974: The nature and properties of soils. McMillan Publ. Co., NY.

Maximum Daily Rainfall observed
187 cm/day - Reunion

Profile	Depth (cm)	Horizon Description	Upper Limit Infiltration Rate (cm/day)
RP-1	10	A/B	5,760
	40	C/Bt Clay in fractures	26
	80	C/Bt Clay in fractures	19
RP-2	40	Bt2	9
	80	Cox/t Saprolite with clay in fractures	55
RP-3	40	Cox/t Saprolite with clay in fractures	180
	80	Cox/t Saprolite with clay in fractures	160
RP-4	10	Bw/C Disturbed horizon	14,400
C-1	10	Bt	60
	120	Saprolite	180
	300	Saprolite	85
C-2	50	Bt	85

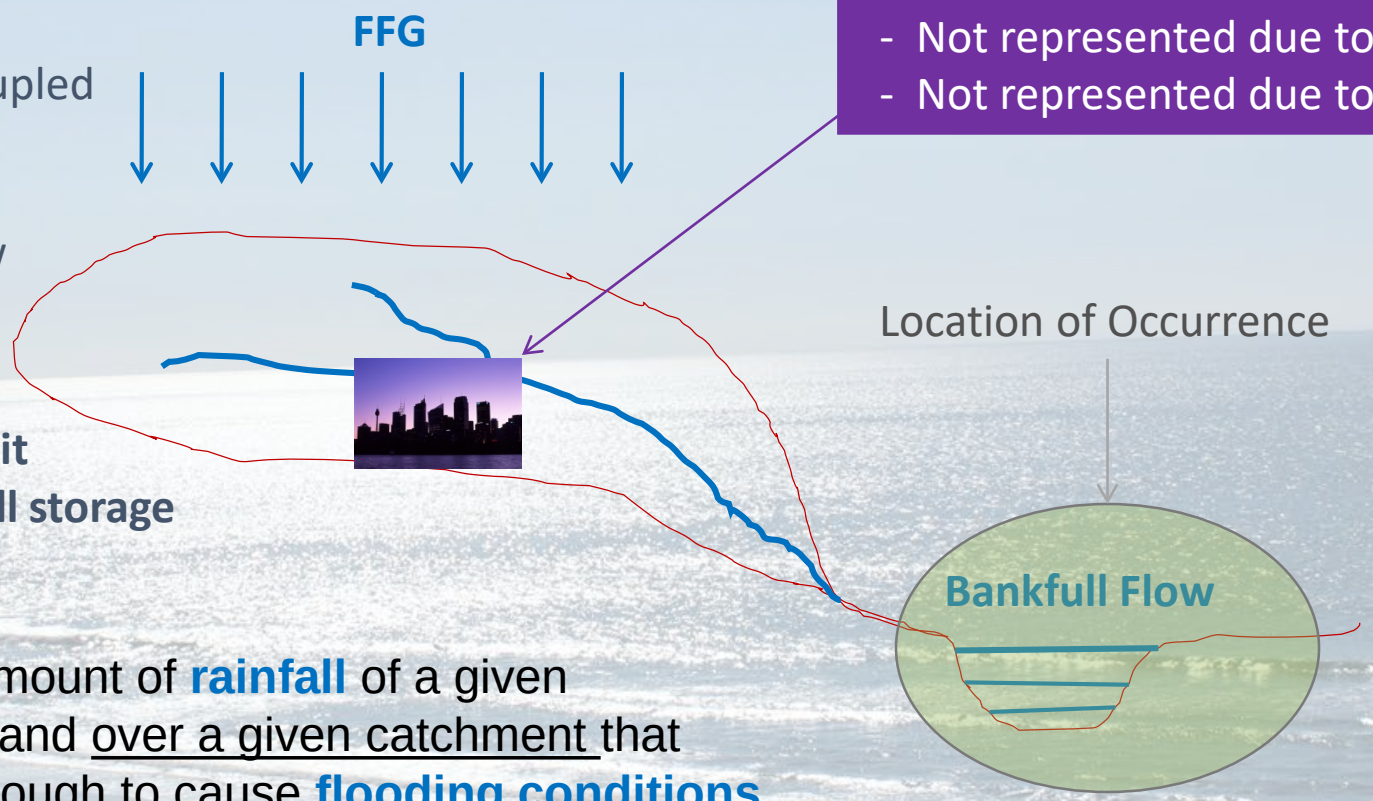
Harmon, R.,S., (ed.) 2005: The Rio Chagres, Panama. Springer, The Netherlands.

FFG Fundamental Concepts

Rainfall threshold (familiar concept)

Meteorology and hydrology decoupled for adjustments

Concerned only with bankfull flow



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!

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:

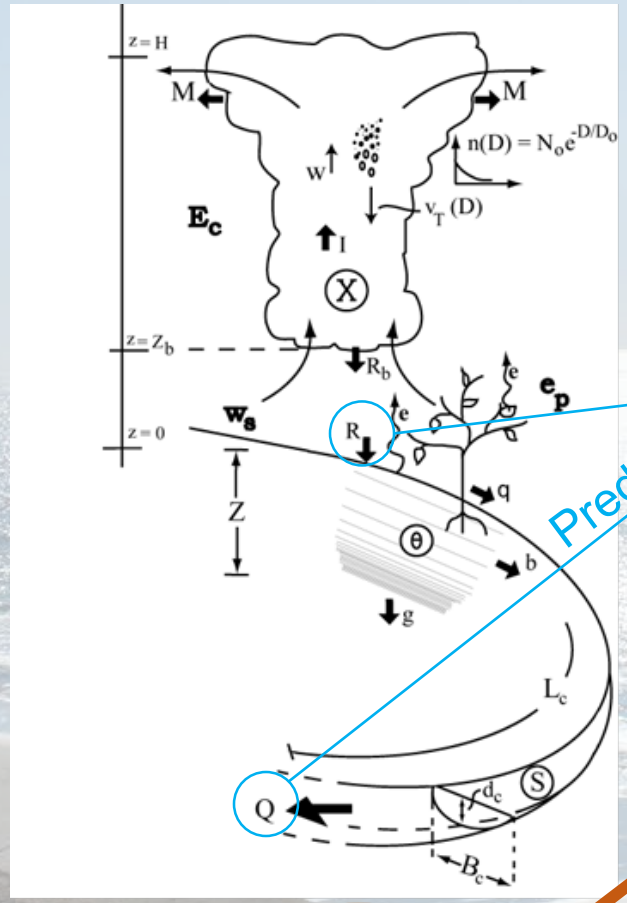
the United Nations – World Meteorological Organization (WMO)

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).

http://www.wmo.int/pages/prog/hwrp/flood/ffgs/index_en.php

Integrated Systems for Real-Time Warning



Observations or Forecaster Experience

Last-Minute Information

Forecast

ε

Predictions

Decision to issue warning

Response

Warning Message

Adjustments

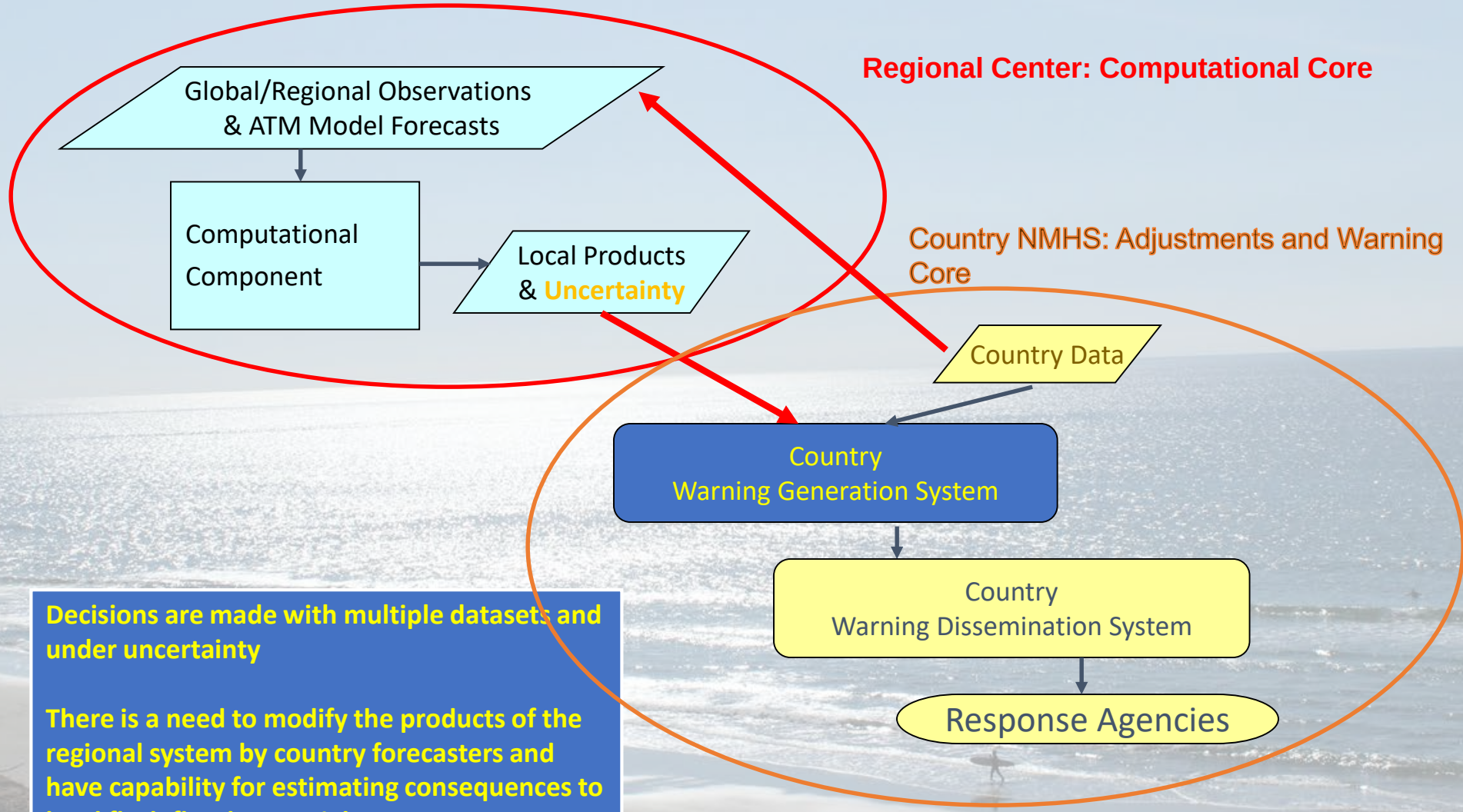
Decision Maker Guidelines and Preferences

Agency-Coordination Education Programs

Modeling Systems

Training and Local Experience

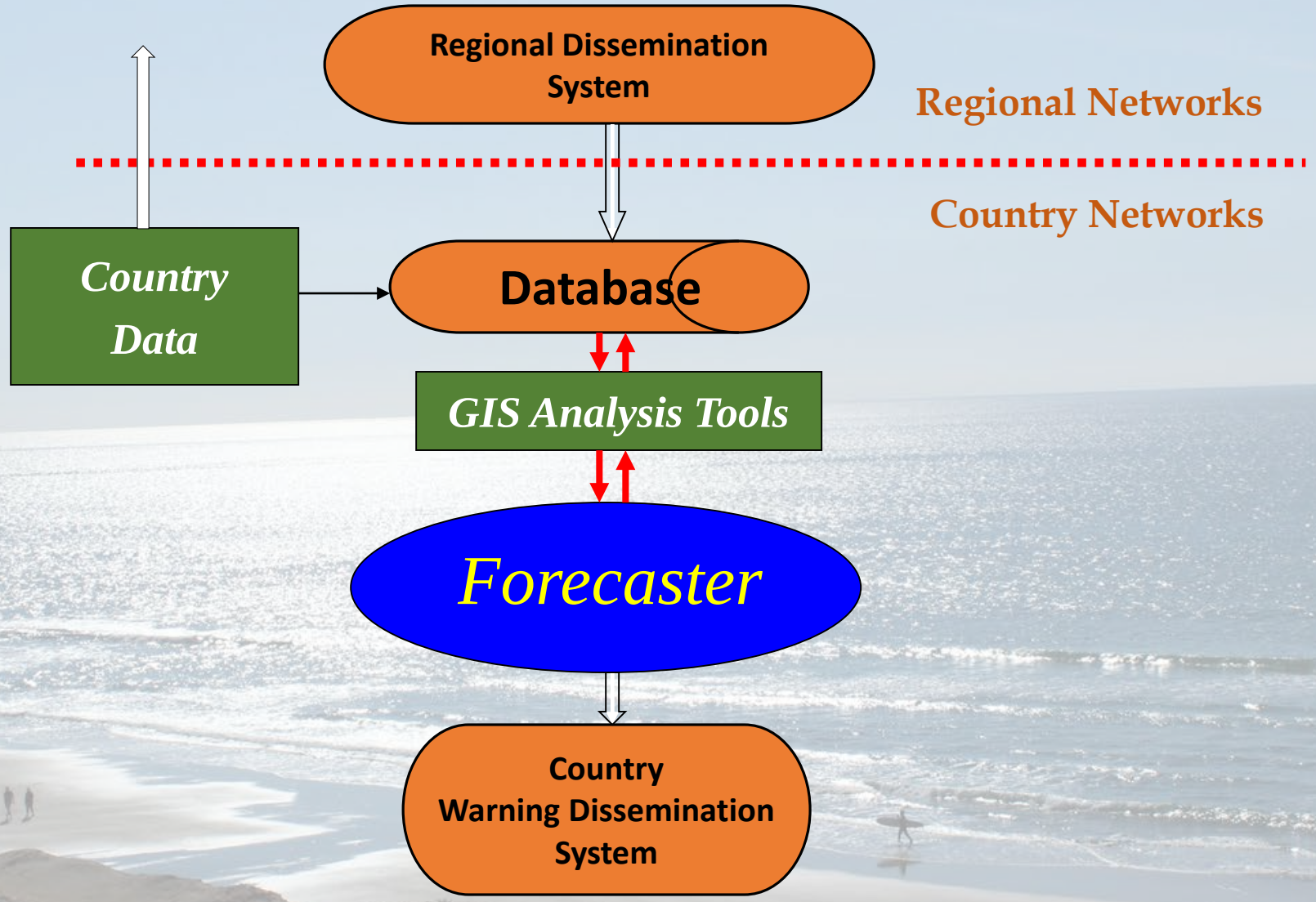
FLASH FLOOD GUIDANCE SYSTEM
From Global Data and Regional Hydrometeorology to Country Data and Warnings



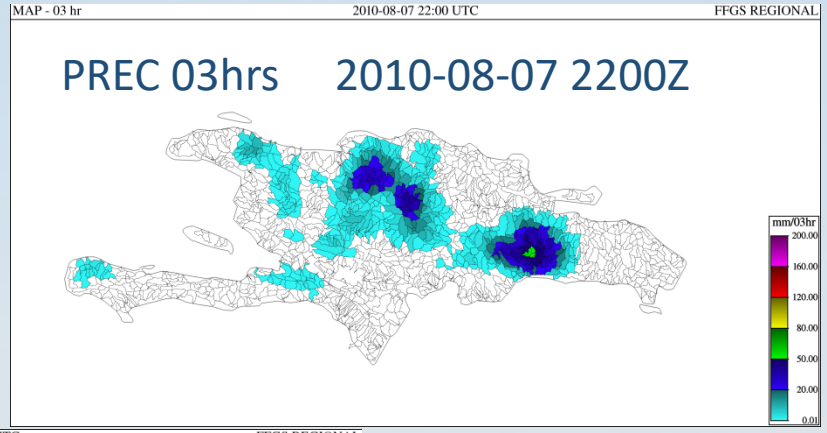
Decisions are made with multiple datasets and under uncertainty

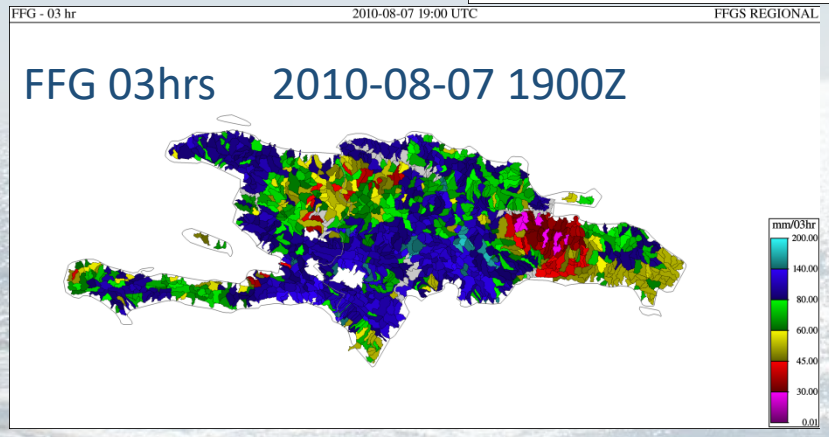
There is a need to modify the products of the regional system by country forecasters and have capability for estimating consequences to local flash flood potential

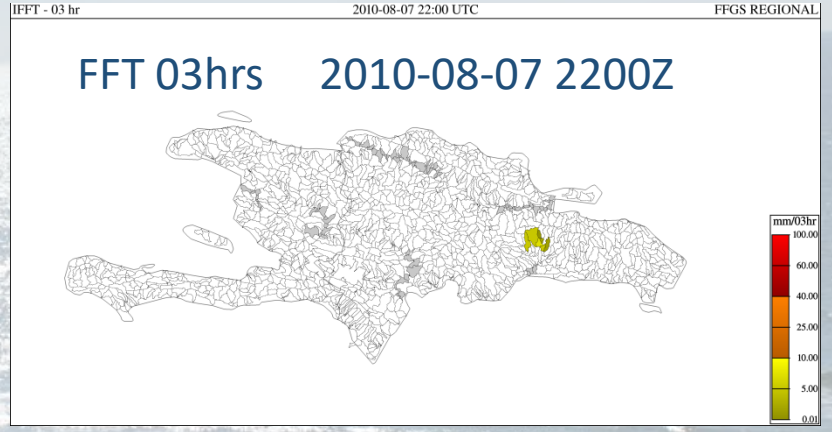
Local System for Warnings



Application of Flash Flood Guidance

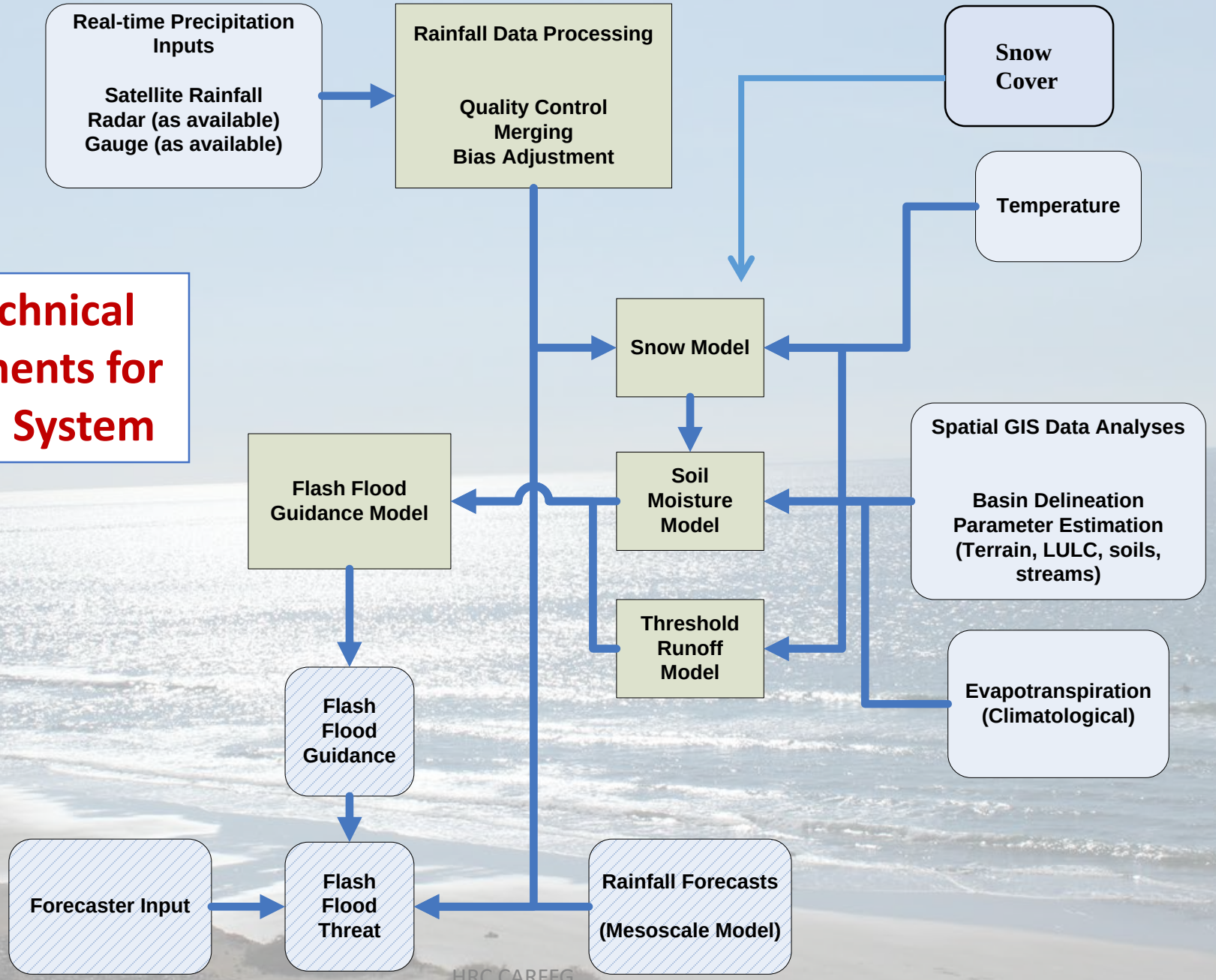






Flash Flood Guidance (FFG): **The amount of actual rainfall of a given duration over a small basin required to generate flooding flows at the outlet of the basin.**

Key Technical Components for the FFG System



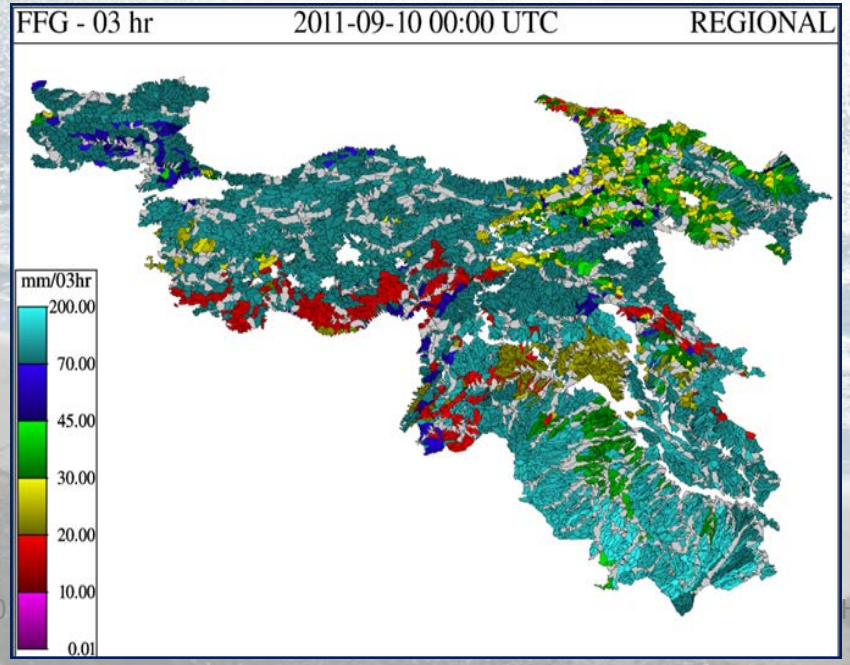
Global Flash Flood Guidance Products

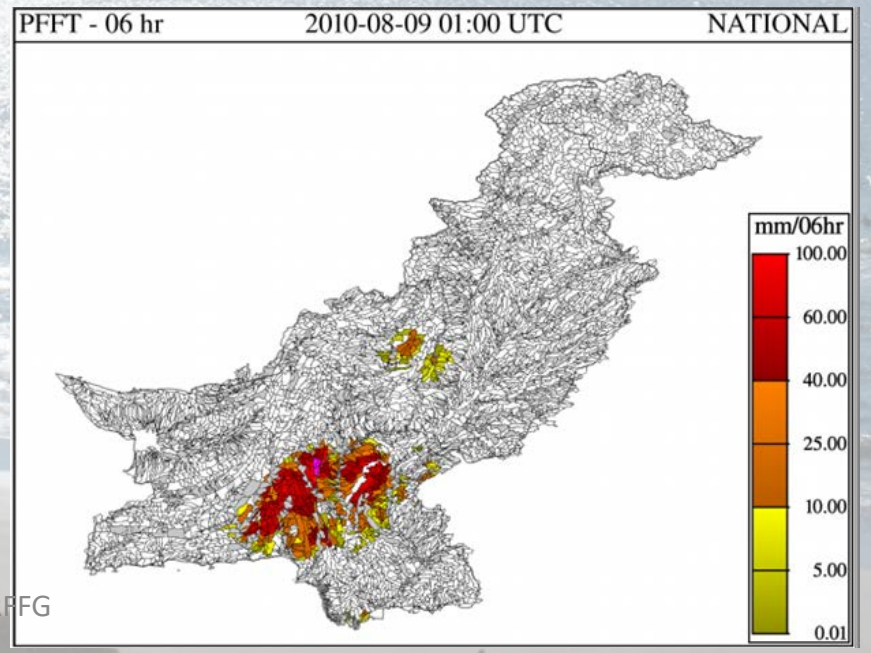
DIAGNOSTIC

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**)





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.)

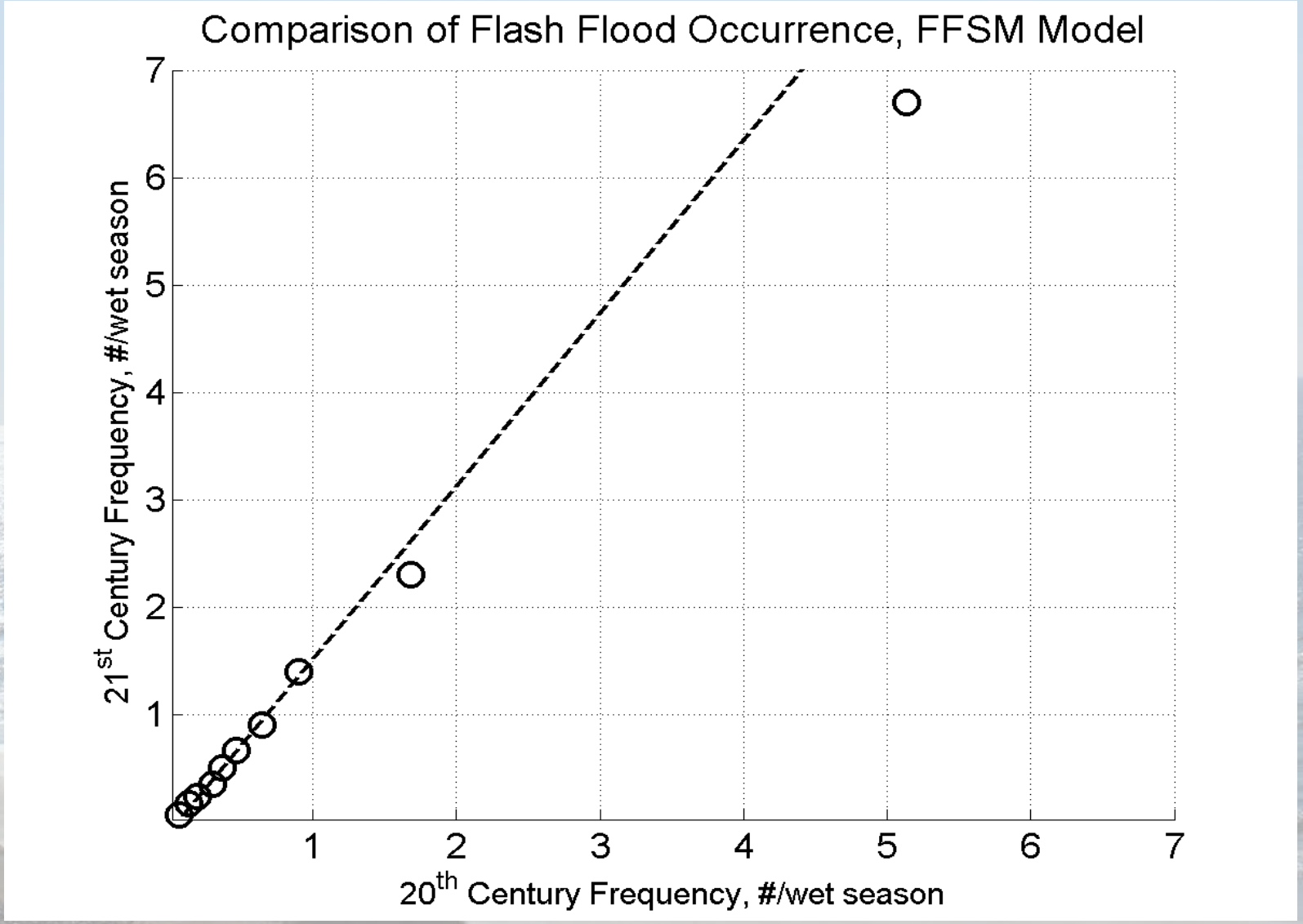
Links of regional center to national real time databases for reduction of uncertainty in precipitation input and increase of reliability

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)



FFG Development Team at HRC

Kosta Georgakakos – Technical Director/Hydrometeorology

Robert Jubach - Program Management/Disaster Risk Reduction

Jason Sperfslage - IT Systems Engineering

Theresa Carpenter - Mesoscale Modeling and Routing Models

Eylon Shamir – Soil Water and Snow Models

Cris Spencer – IT Engineering/Programming

Ari Posner – Land Slides/EOS Data Evaluation

Rochelle Graham – Education and Training