Flash Flood Guidance System (FFGS) for NW South America - NWSAFFG Overview

HYDROLOGIC RESEARCH CENTER

21 February 2018

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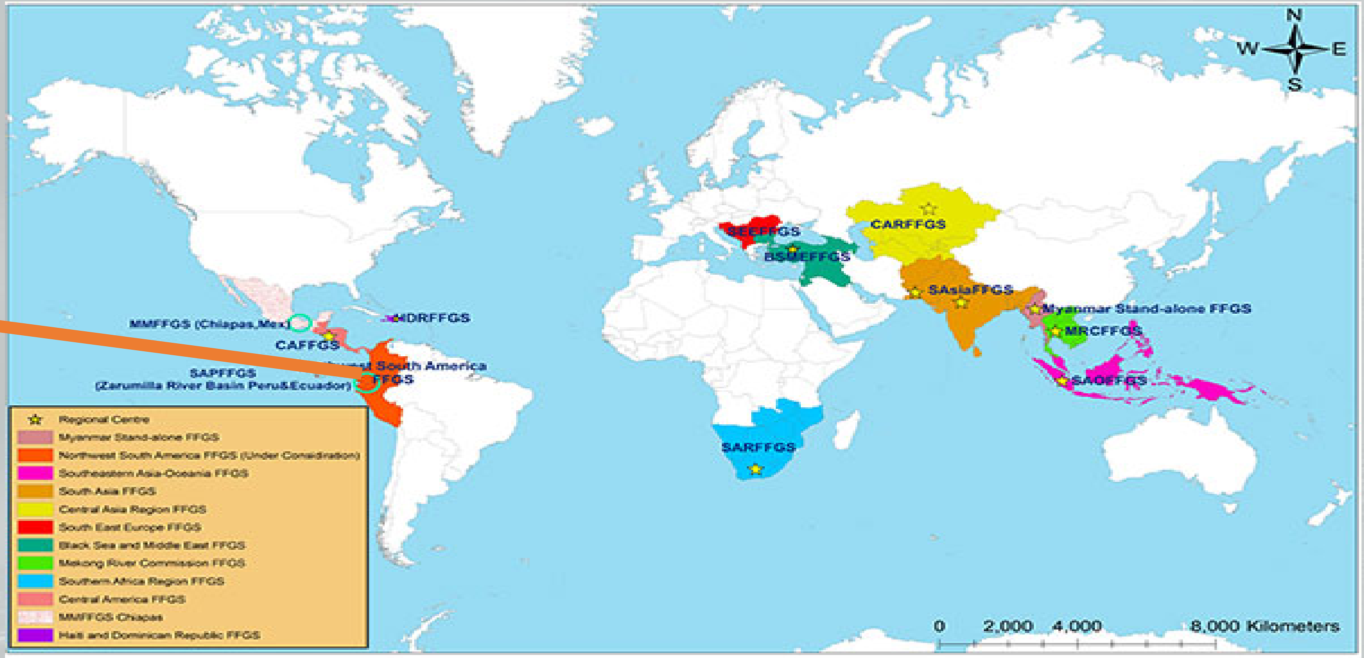
Region of Application



The Global Initiative for Flash Floods
WMO – USAID/OFDA – NOAA - HRC

To implement regional flash flood guidance systems worldwide in support of forecasters generating operational flash flood forecasts and warnings

Role of HRC

In collaboration with USAID, WMO, NOAA and Countries

Developed the FFGS concept and system design

Tailors FFGS systems for specific regions (data, geomorphology and hydrometeorology)

Implements system at a regional center in the region

Trains Forecasters in flash-flood hydrometeorology, and in the FFGS components and interface use for warnings

Provides GHE (with agreement with NESDIS) and MWGHE (value added to GHE) to regional systems

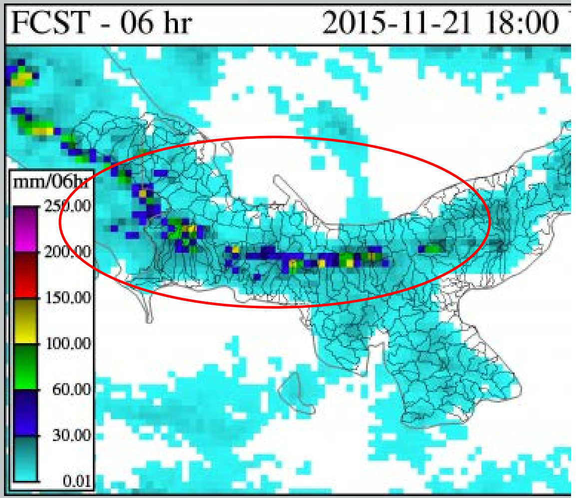
Maintains and enhances FFGS system implementations

IMAGINE A PANAMA FORECASTER ON 1:00PM LST 21 NOVEMBER 2015 (Saturday)

Panama Time = UTC – 5 hours

It has been raining in Western Panama ….

What is the rainfall fore
FFG System WRF shows:



Home » News » Panama » 12 homes affected in Boquete floods

12 homes affected in Boquete floods

Posted on November 22, 2015 in Panama

HEAVY DOWNPOURS throughout the weekend led to flooding and land slides in Chiriqui and Bocas Del Toro with at least 12 homes affected in the district of Boquete.

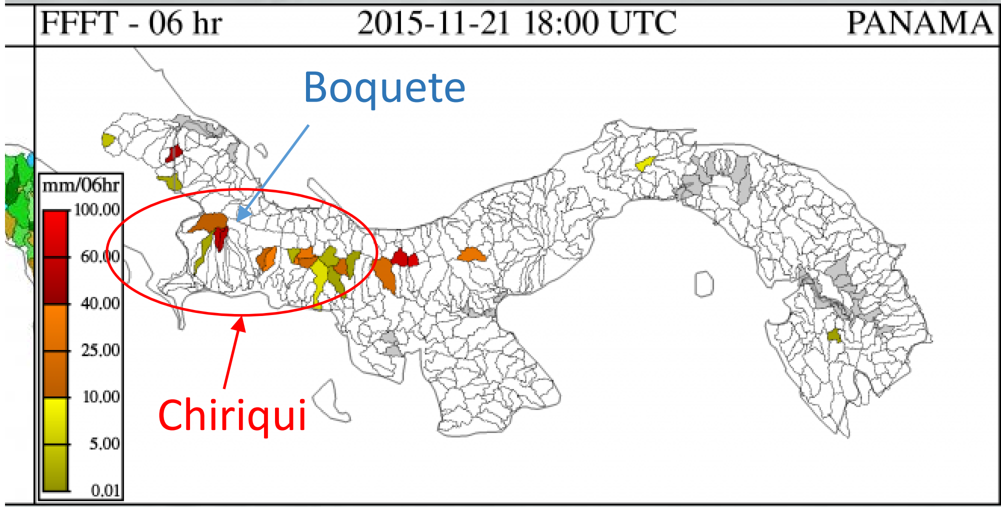
Share:

Post Views: 562

The Joint Task Force (FTC), led by the National Civil Protection System (Sinaproc), said the torrential rain has wreaked havoc in several localities in western Panama, near the border with Costa Rica.

land?
ction:

Which small basins are at risk?
FFG System Flash Flood Threat shows:



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:

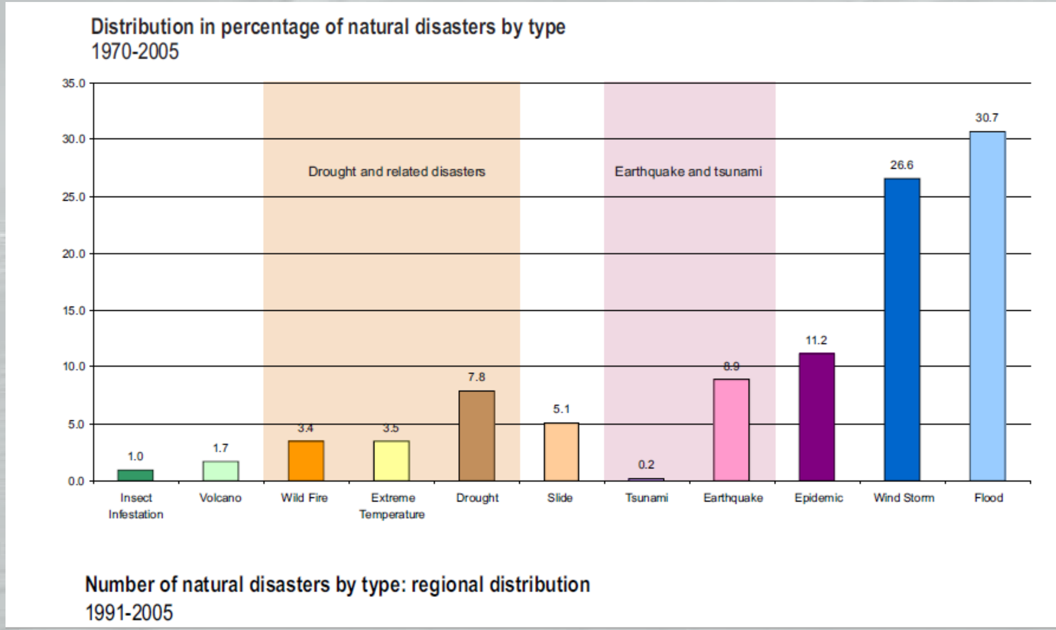
1. BOTH Hydrological and Meteorological expertise for real time forecasting/warning
2. Knowledge of local up to the hour information for effective warning

Usually, flow crest is reached within 6 hours of causative event

Why worry about Flash Flooding?

- "Recent findings of the WMO (2008) country-level survey where of the 139 countries, 105 indicated that *flash floods were among the top two most important hazards around the world and require special attention"*
- On the average, these events kill over 5,000 unsuspecting people and cause millions of dollars of property damage
- Highest mortality rate (people affected / people lost)

U.N. International Strategy for Disaster Reduction



Why Worry About Flash Flooding?

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
- Climatic changes in several regions increase precipitation intensity

What are natural flash flood causes?

- 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)

Why is flash flooding different from large river flooding?

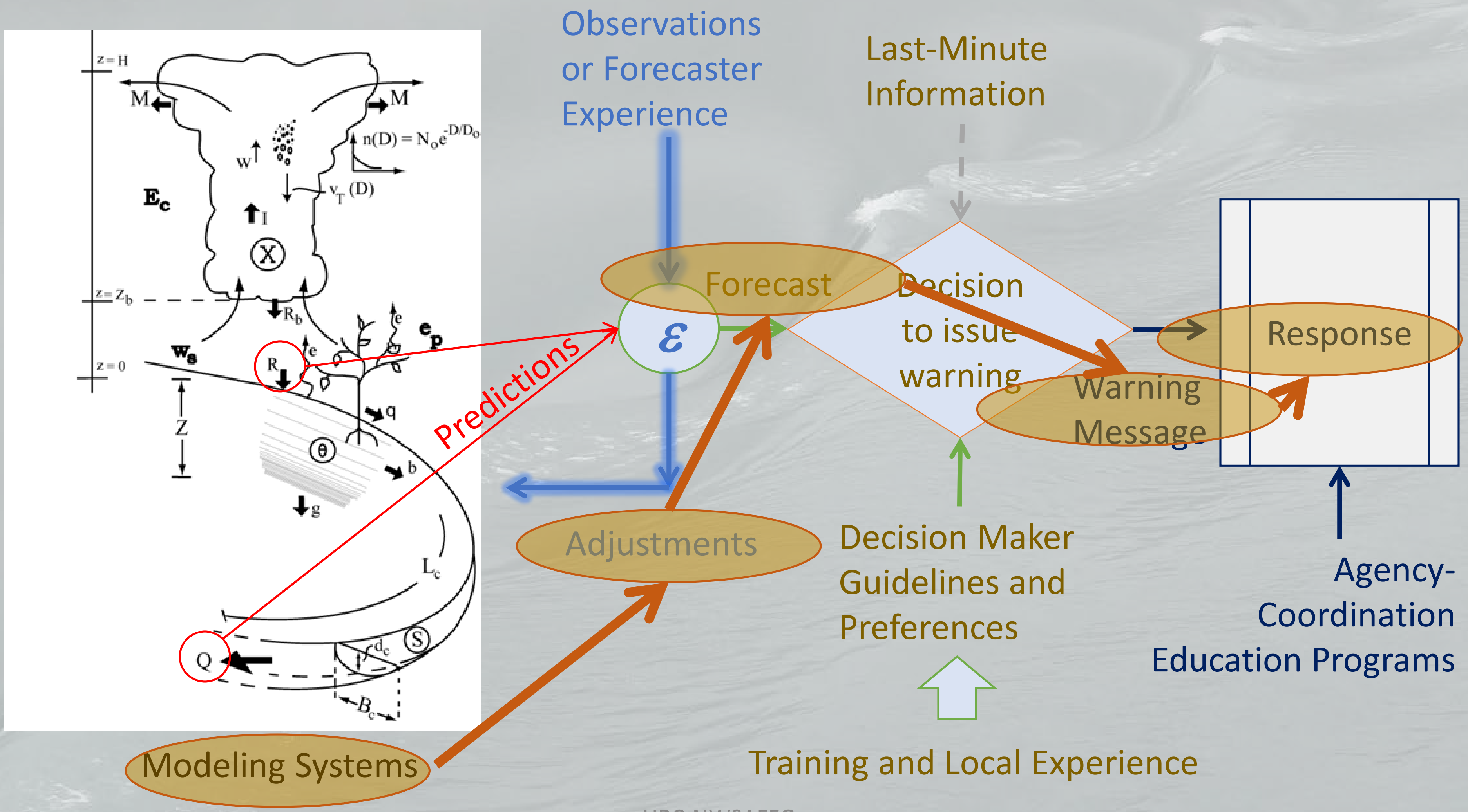
LRF

- *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

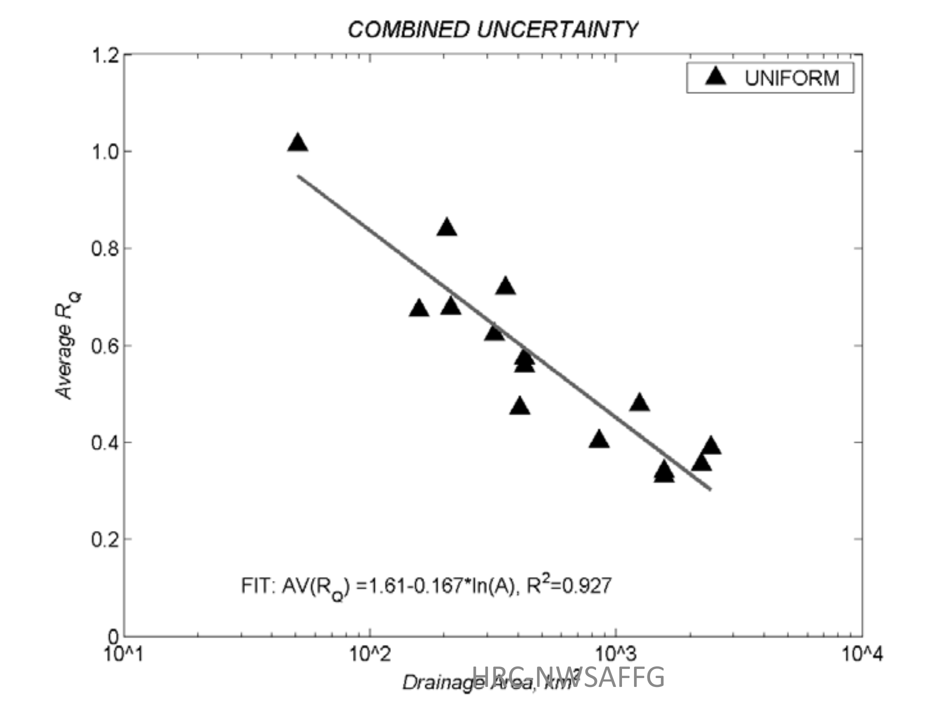
- *Catchment response is very fast and allows very short lead times (< 12hrs)*
- *Prediction of occurrence is of interest*
- *Local information is very valuable*
- *A truly hydro-meteorological forecasting problem*
- *Coordination of forecasting and response is challenging over short times (Careful Planning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

Program Design to Support Integrated Systems Perspective for Real-Time Warning



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

Operational Utility of Systems with Forecaster Adjustments

- Trained forecaster adjustments have a beneficial effect on warning reliability especially for local bias situations

  (Use of up to the minute information from the field very useful; Real-time cooperation of meteorologists and hydrologists very useful for effective adjustments)

- In-depth training of forecasters in system model behavior is required for sustainability

  (In most cases several-month efforts are required)

- A priori and real-time coordination of forecasters with response agencies necessary for high utility

- Local experience of forecasters invaluable for warnings against short-fuse hydrometeorological phenomena – Validation/Databases

  (Mesoscale model biases; hydrologic model biases; local soil behavior and flooding conditions)

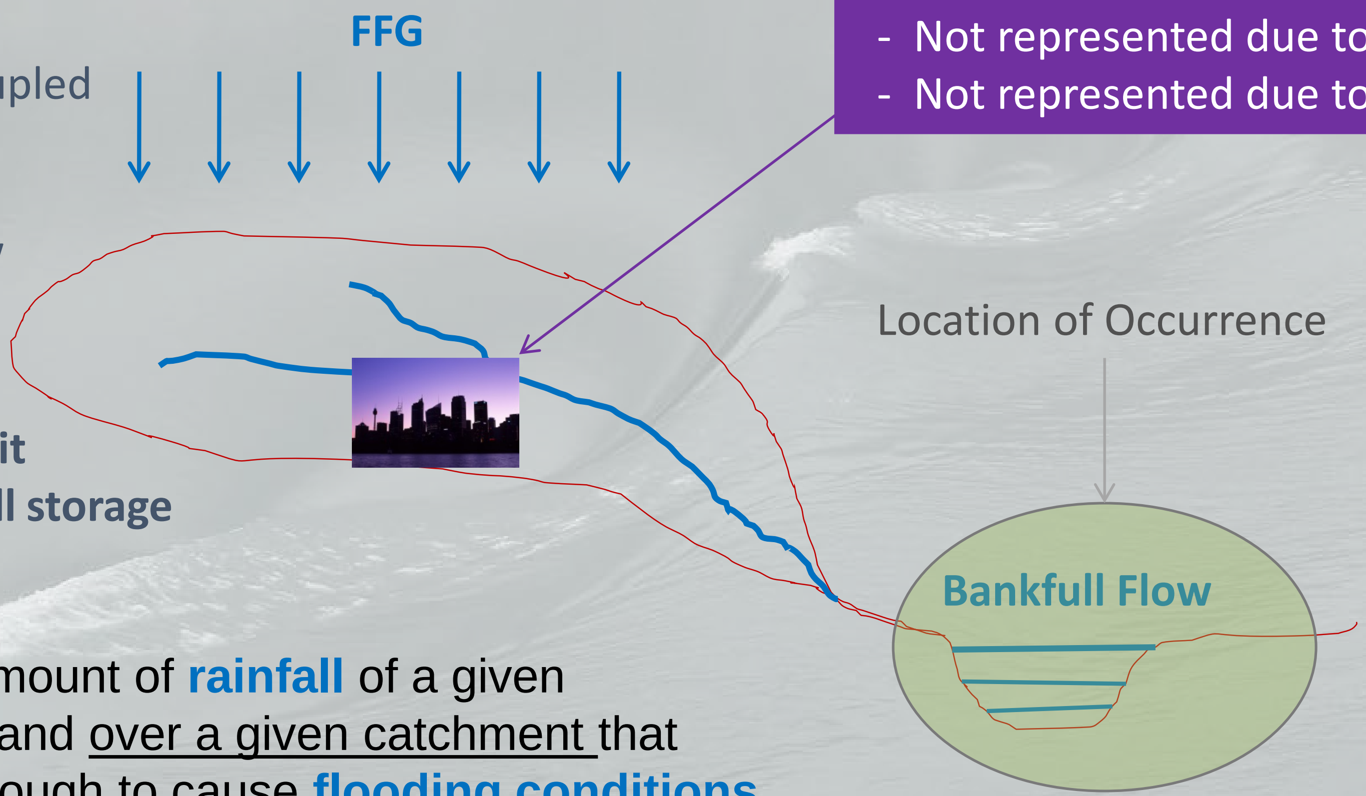
What is flash flood guidance?

Rainfall threshold (familiar concept)

Meteorology and hydrology decoupled for adjustments

Concerned only with bankfull flow

Urban environment treated differently
- Not represented due to scale
- Not represented due to storm sewers



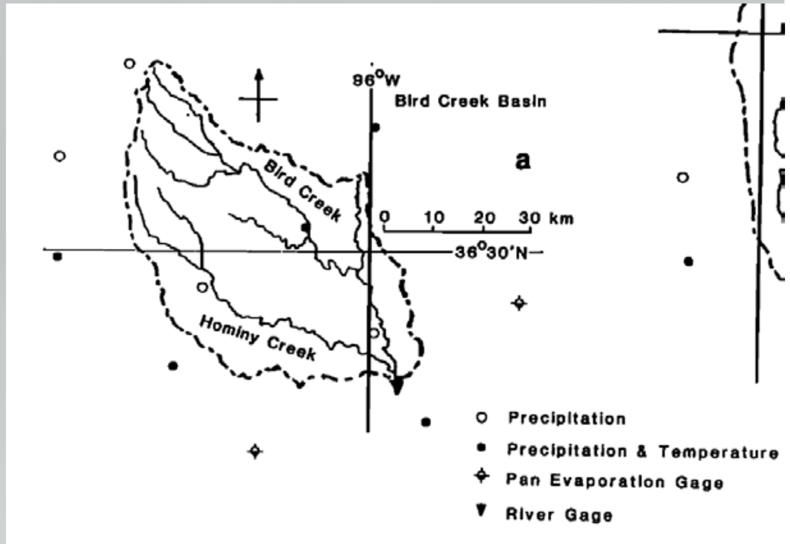
Soil Water Deficit
Channel bankfull storage

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!

Why is soil water important for flash flooding in addition to rainfall rate? –Summer Convection

Georgakakos et al. *WRR* **31**(3), 210-220, 1995.



658 GEORGAKAKOS ET AL.: HYDROCLIMATOLOGY OF WATERSHEDS, 1

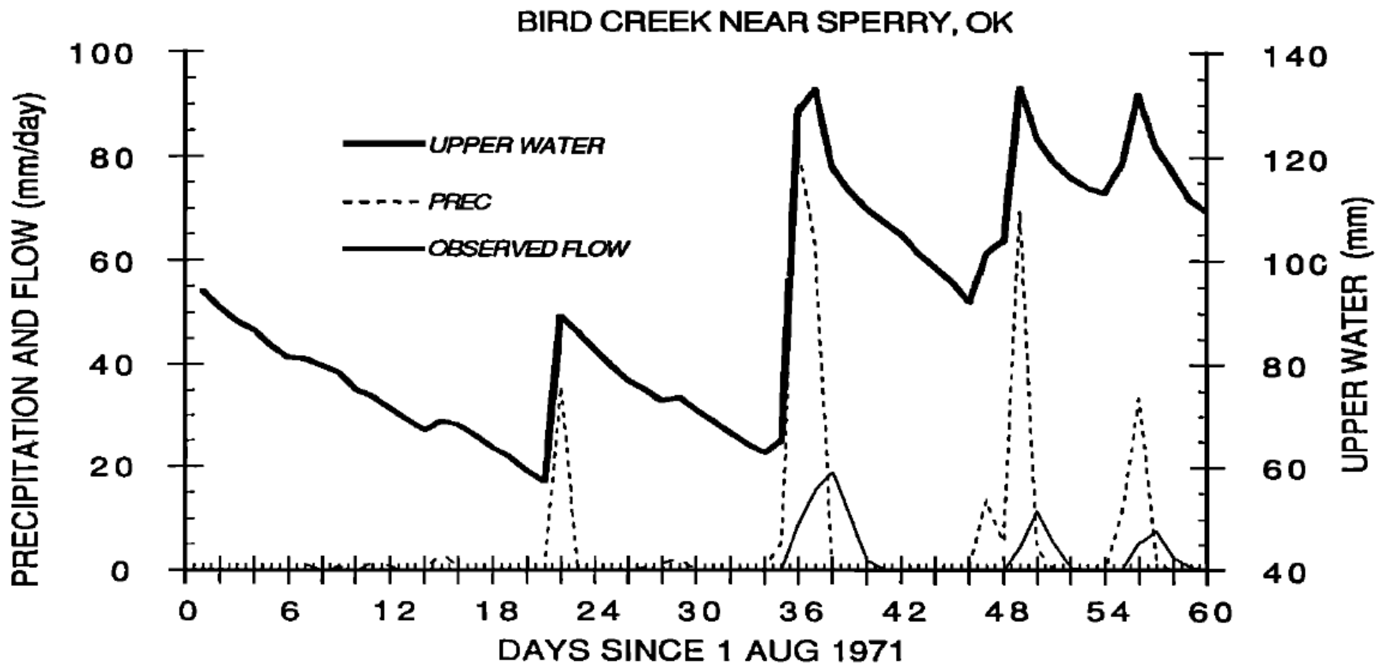


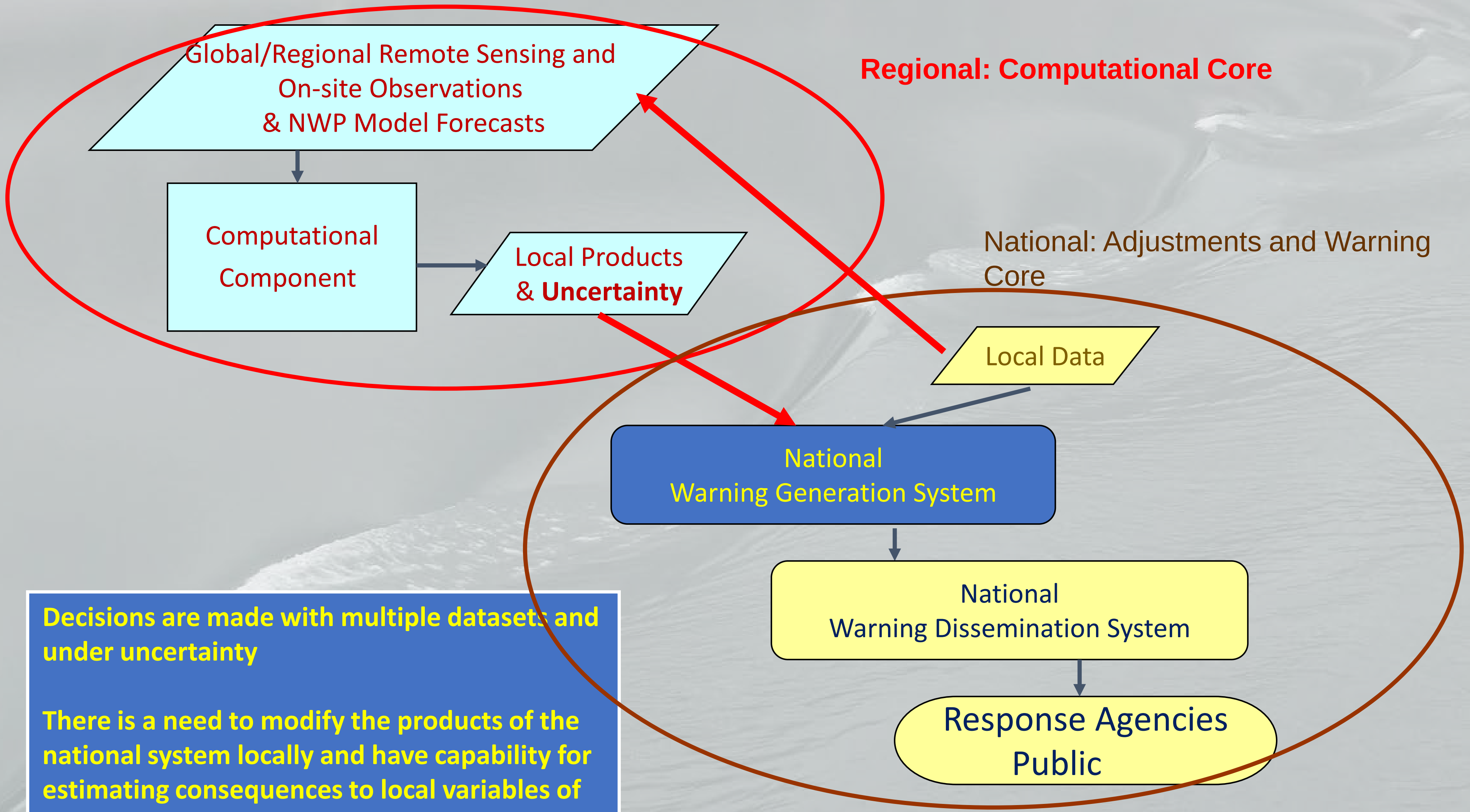
Figure 2. Daily values of rainfall rate (dashed line), flow rate (solid line), and upper soil water (heavy solid line) for Bird Creek near Sperry, Oklahoma, for August and September 1971. Rainfall and flow rates are in millimeters per day and are read on the left ordinate axis. Upper water is in millimeters and is read on the right ordinate axis. Upper water capacity is 135 mm.

Research and development history

- **1970-1988**: US NWS Produces **FFG statistically** for each River Forecast Center. Also, **research** in adaptive site specific FF prediction systems.
- **1988-1993**: IIHR/HRC develop **physically consistent FFG formulations based on GIS** and create the first operational codes for US NWS
- **1993-2005**: HRC continues **research** in various aspects of the FFG process and system (sparsely gauged basins and uncertainty issues, forcing and models). The development of **prototype regional systems** using FFG is proposed and accepted in work plan of **WMO CHy Working Group on Applications (2002-2003)**
- **2004**: The **Central America Flash Flood Guidance System becomes operational** (serves 7 countries in CA)
- **2008: WMO, USAID, NOAA, HRC sign a quad-part Memorandum of Understanding to collaborate in the development of a global flash flood guidance system (currently completed a 10-year phase)**

FLASH FLOOD GUIDANCE SYSTEM

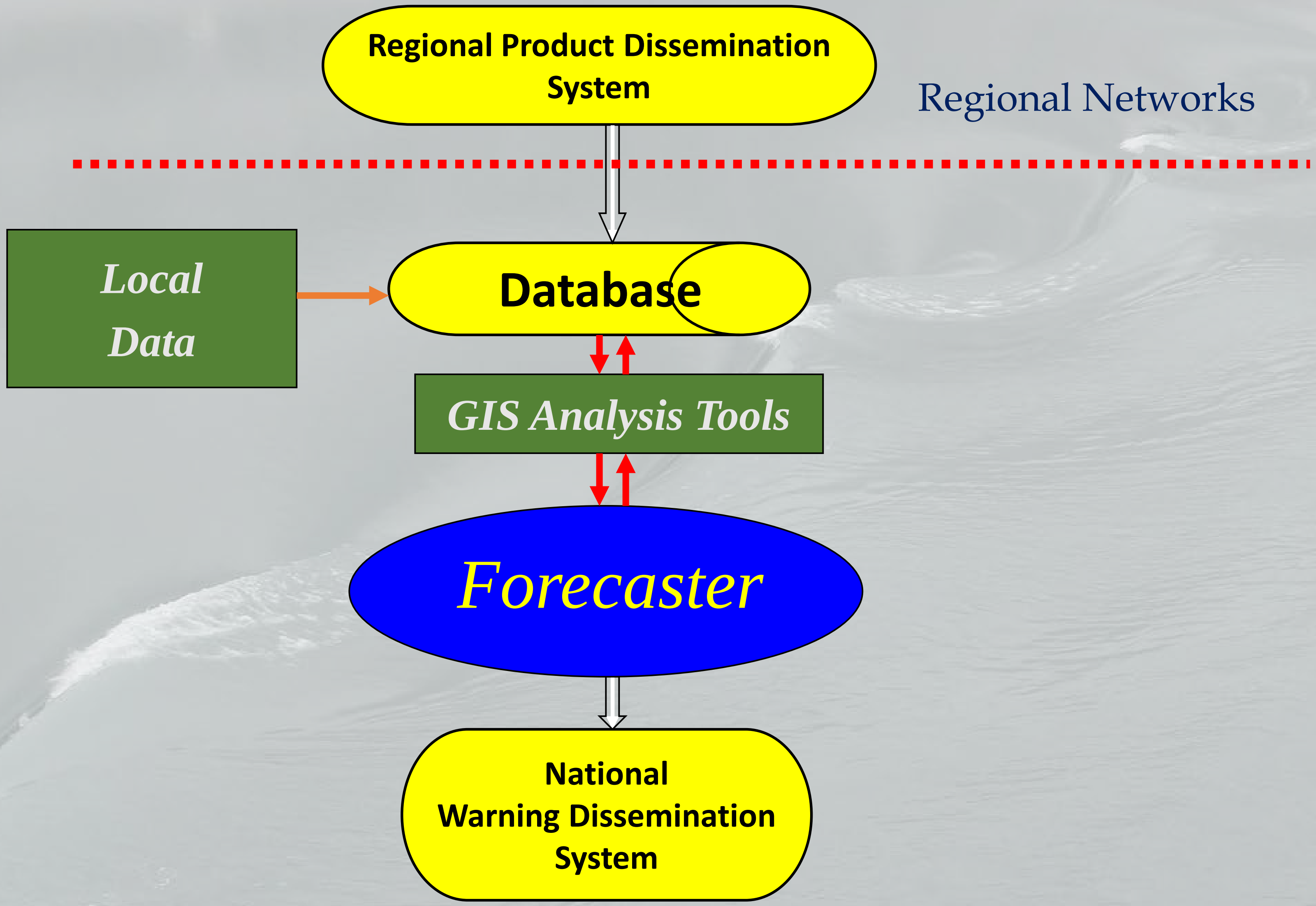
From Global Data and Regional Hydrometeorology to National Data and Warnings



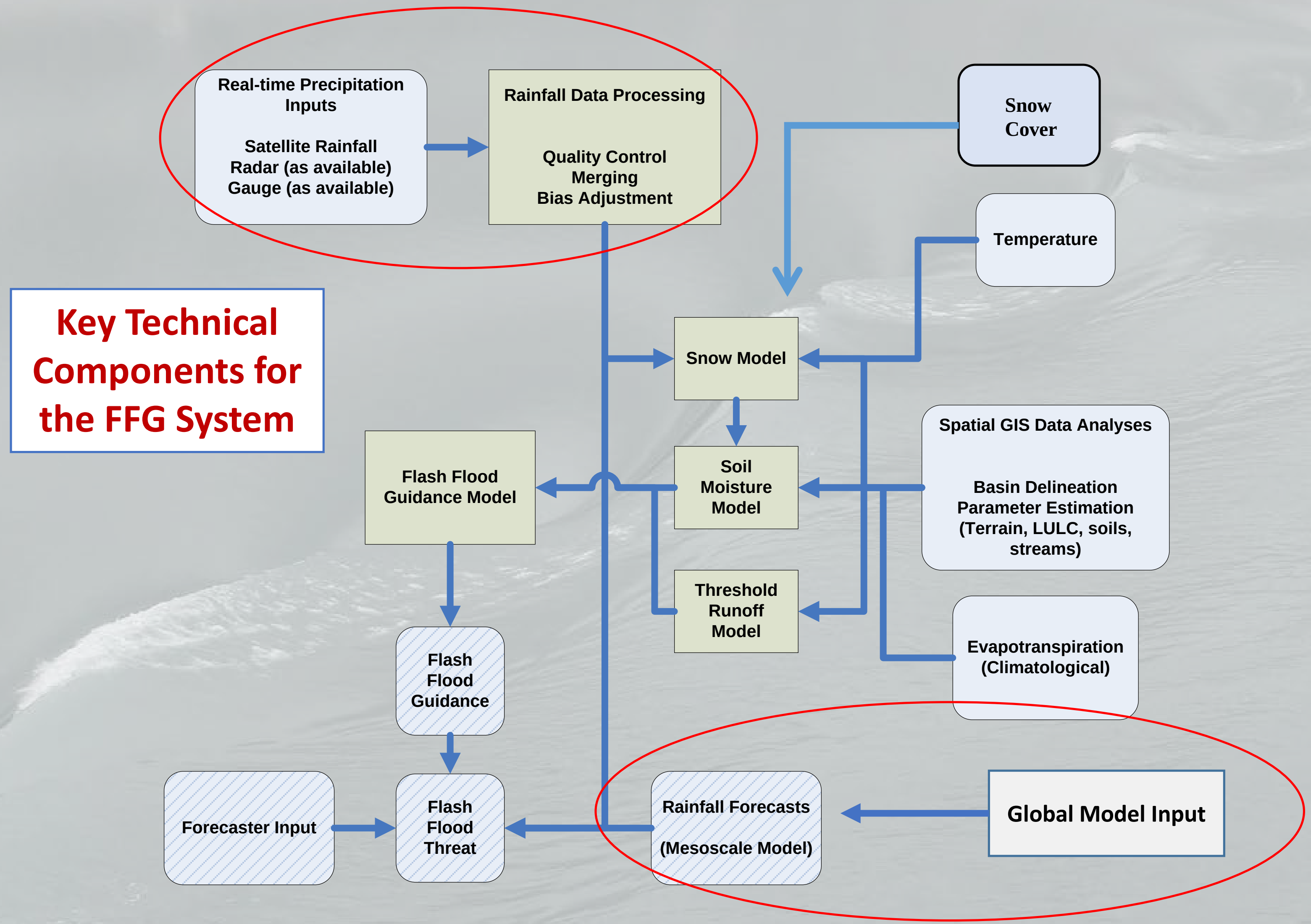
Decisions are made with multiple datasets and under uncertainty

There is a need to modify the products of the national system locally and have capability for estimating consequences to local variables of interest

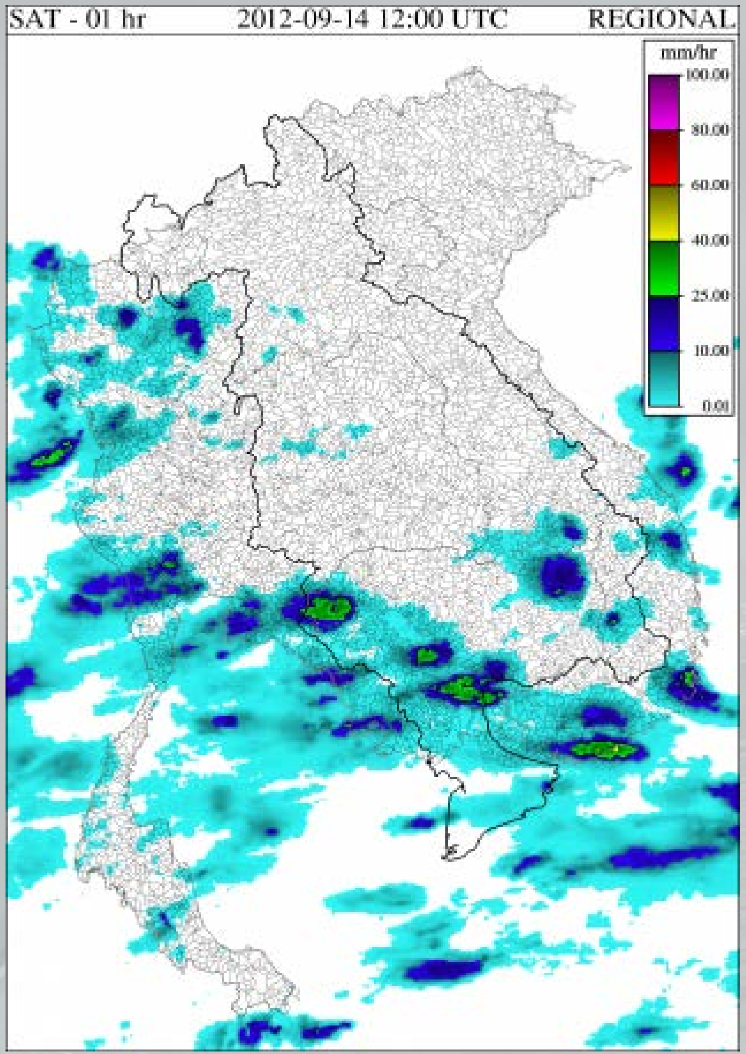
National System for Warnings



SOURCES OF INFORMATION FOR THE FFGS



Satellite Rainfall - Hydroestimator



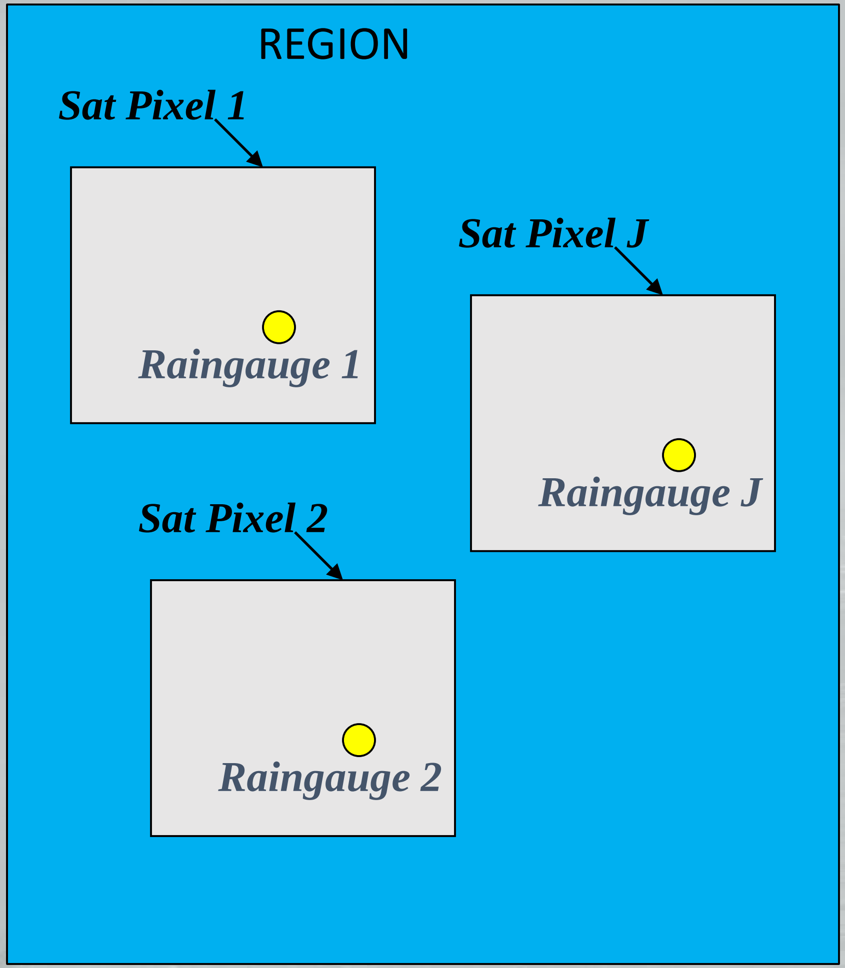
- **IR based (10.7 μm)**
- **Short latency**

Rain Rate =
Function of brightness temperature

Enhanced for:

1. Atmospheric moisture effects
2. Orography (upslope/downslope)
3. Convective Eqlb. Level (warm-top convection)
4. Local pixel T difference with surroundings
5. Convective core/no-core region

Bias and Log-Bias Factors



$$\beta_t = \ln \left[\frac{\sum_{j=1}^{N_g} R_g(t, j)}{\sum_{j=1}^{N_g} R_s(t, j)} \right]$$

Log-Bias

Bias (B)

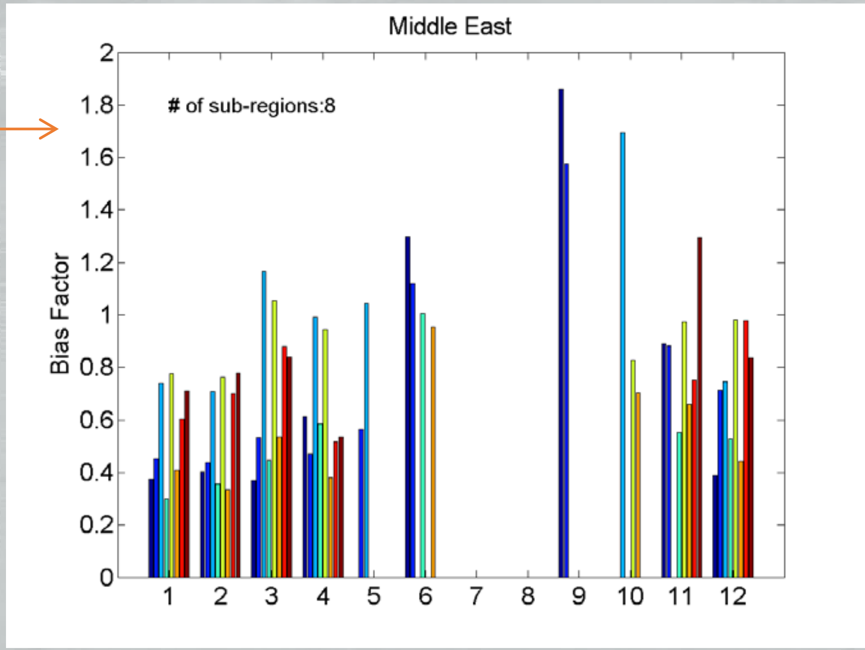
Climatological Adjustment Using Gauges and Corresponding Satellite Pixel Data

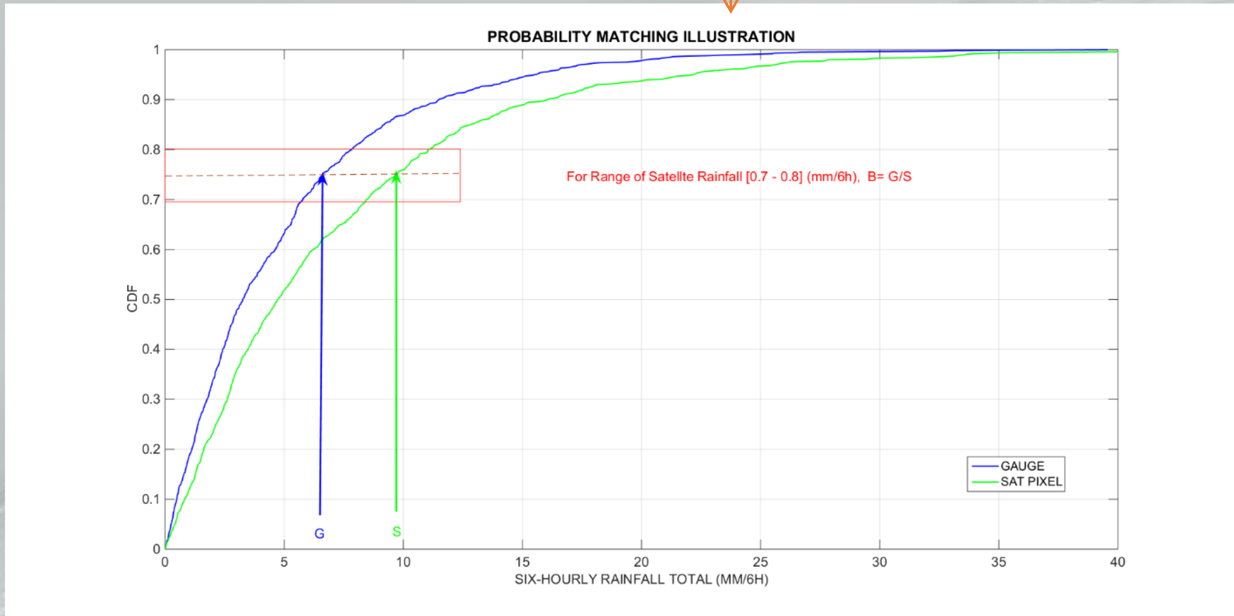
- Historical Data for regions of uniform hydroclimatology, terrain and gauge density
- Usually done for an given month or season
- Result is bias factor for each region and month/season

Bias Factor computed from:

(1) Mean values

(2) Probability matching considerations





Dynamic Bias Adjustment Basics

$$\beta_t = \ln\left[\frac{\sum_{j=1}^{N_g} R_g(t,j)}{\sum_{j=1}^{N_g} R_s(t,j)}\right]$$

$$\beta_{t+1} = \beta_t + w_{t+1}$$

$$z_{t+1} = \beta_{t+1} + v_{t+1}$$

Kalman Filter
Stochastic Approximations

- N pairs of consecutive values
- At least 20% raingauges with rain
- Conditional Mean > Threshold (mm/h) (satellite/radar and gauge)

Bias (B)

Important issue:
Gauge data quality control

Multi-Spectral Satellite Rainfall

HE

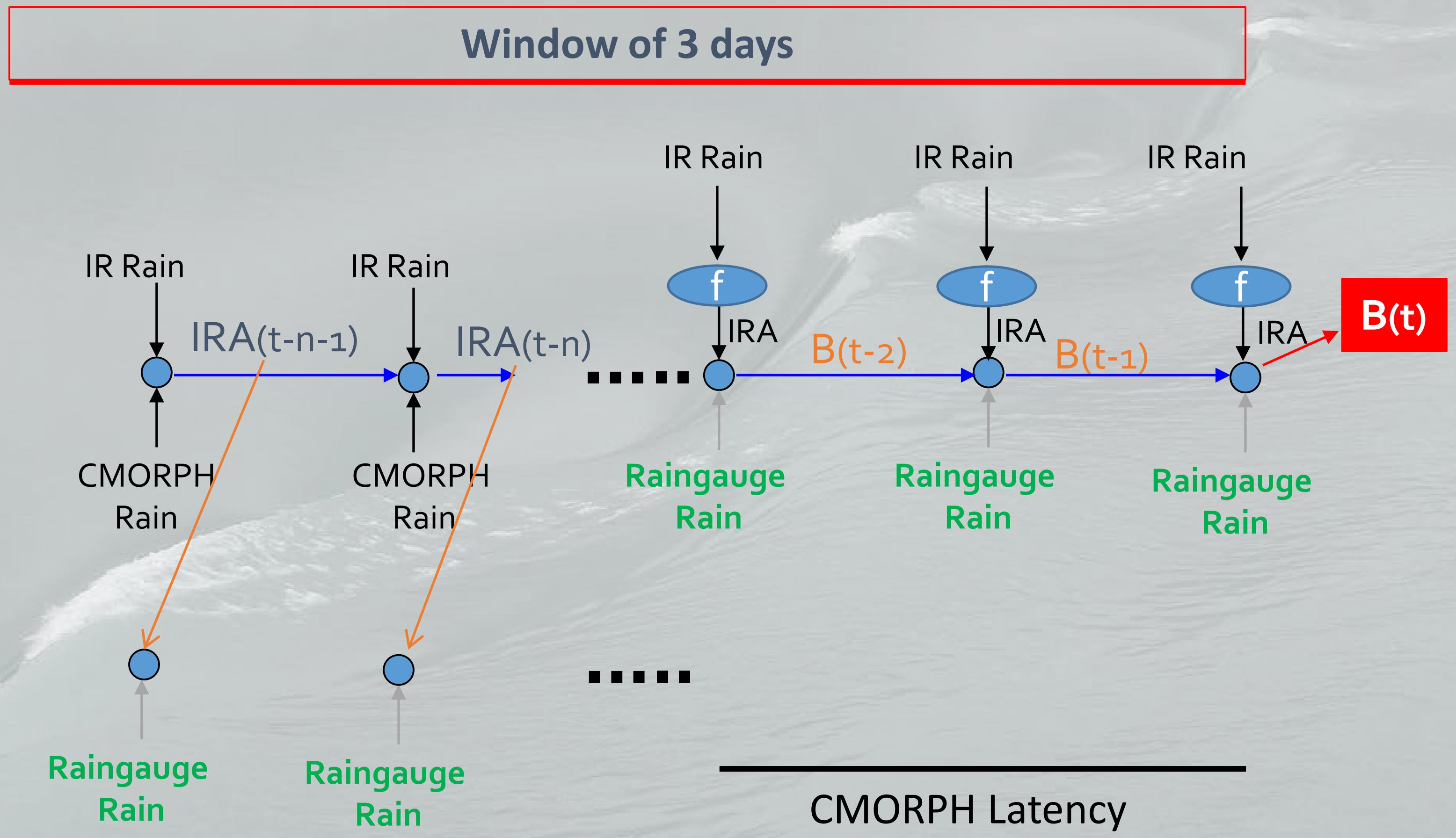
IR – Based
30-min latency in operations
Based on measurements of top cloud brightness temperature

CMORPH

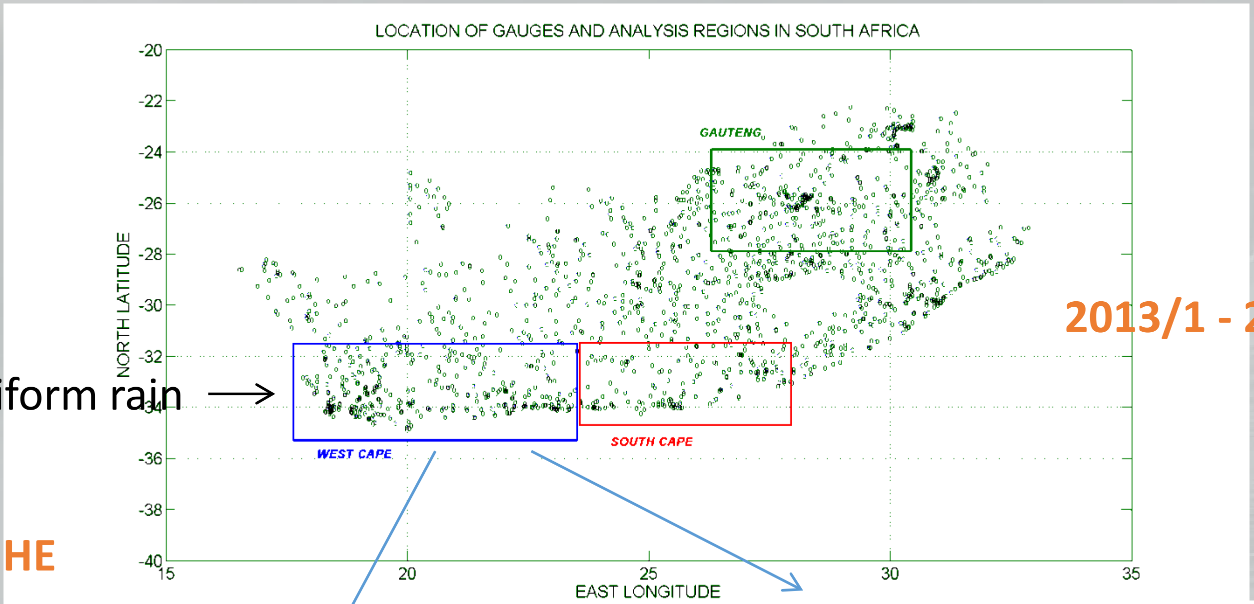
MW – Based
18-26 hour latency in operations
Based on measurements of microwave scattering from raindrops

New global FFGS product combines IR-based HE rainfall with MW-based CMORPH rainfall

Multi-Spectral Satellite Rainfall for FFG Systems



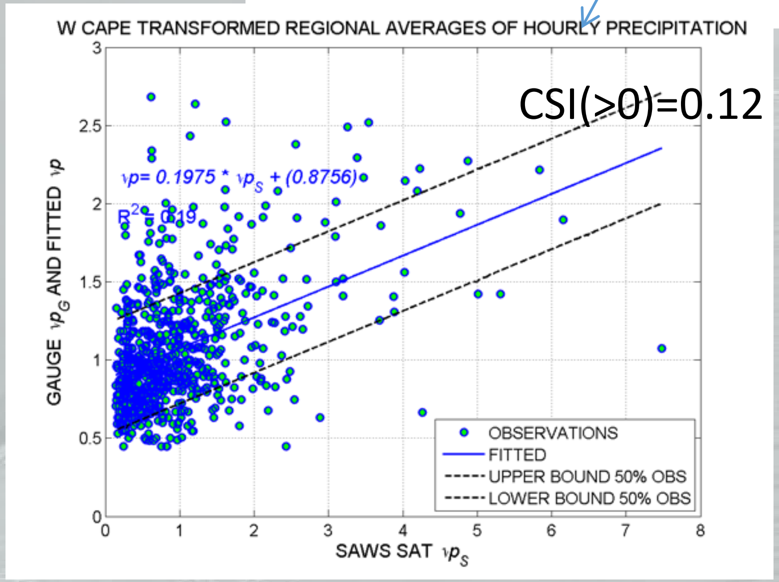
Evaluation from SARFFG



Low Level stratiform rain →

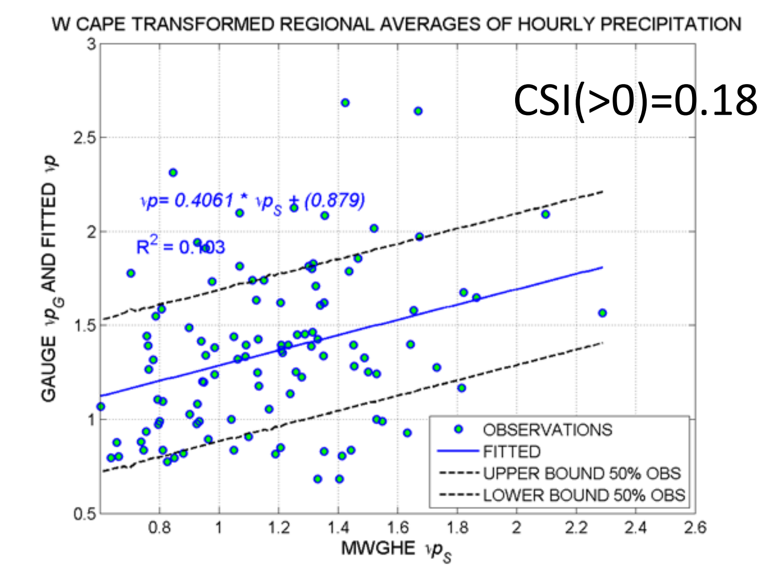
2013/1 - 2014/3

UM Adjusted HE



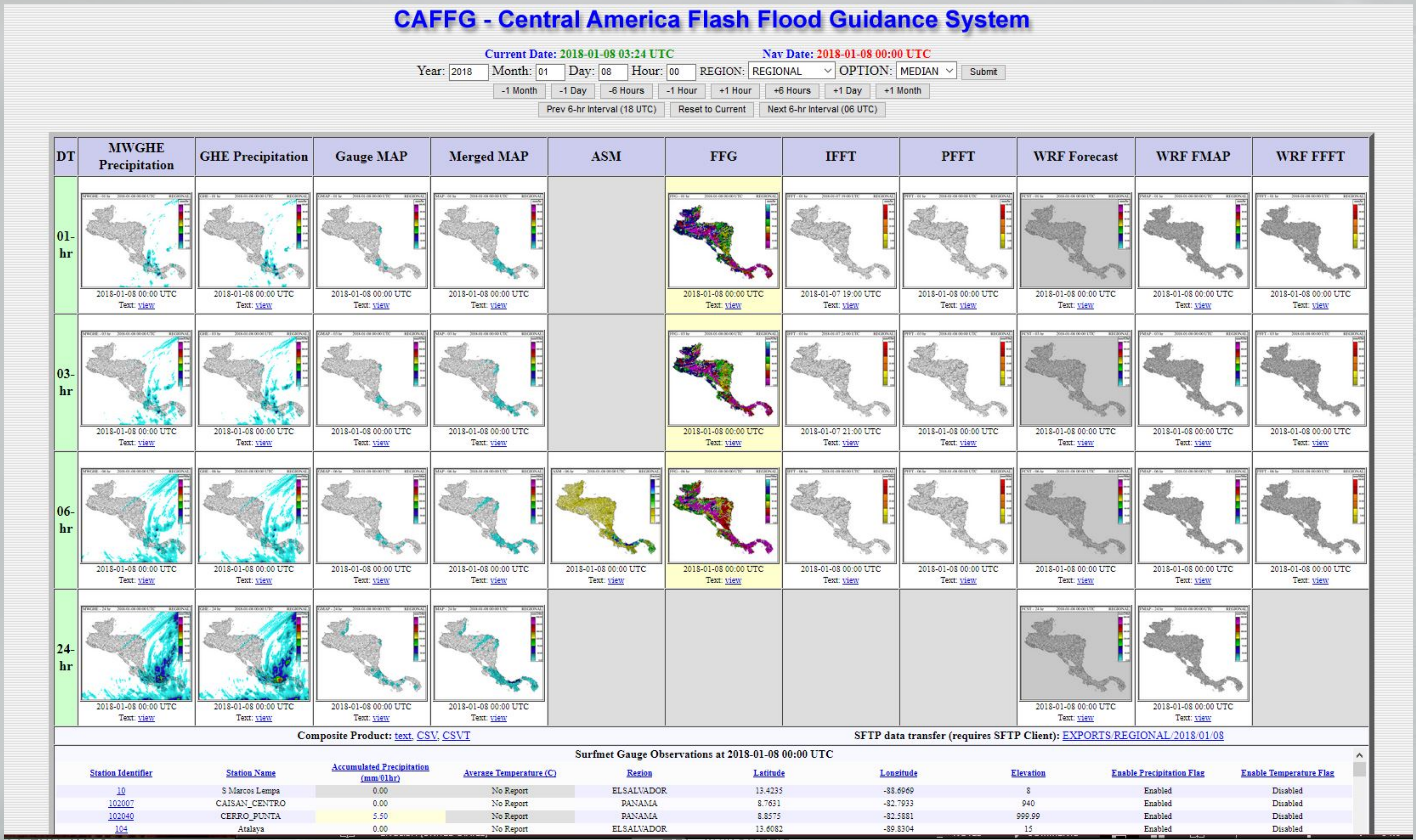
CSI(>0)=0.12

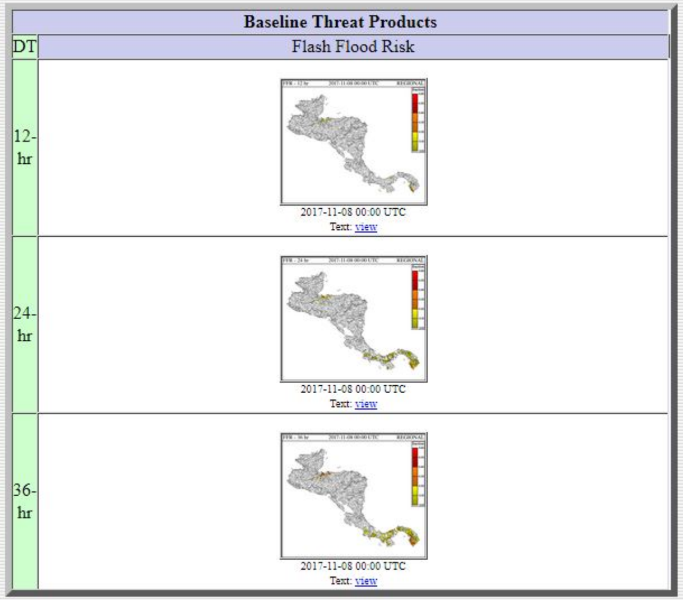
MWGHE

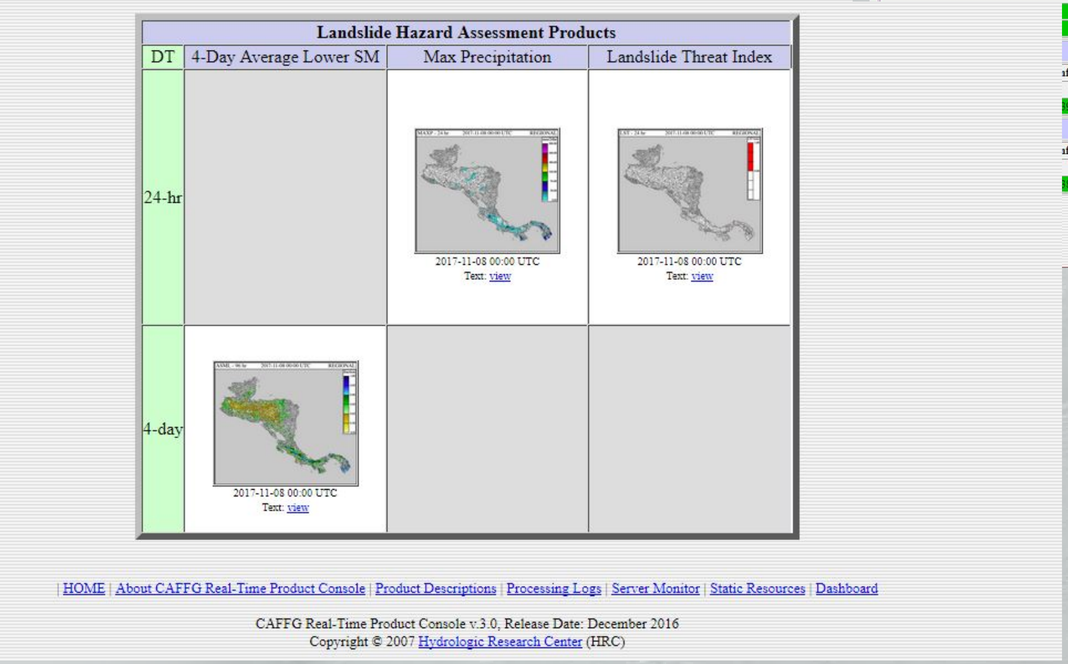


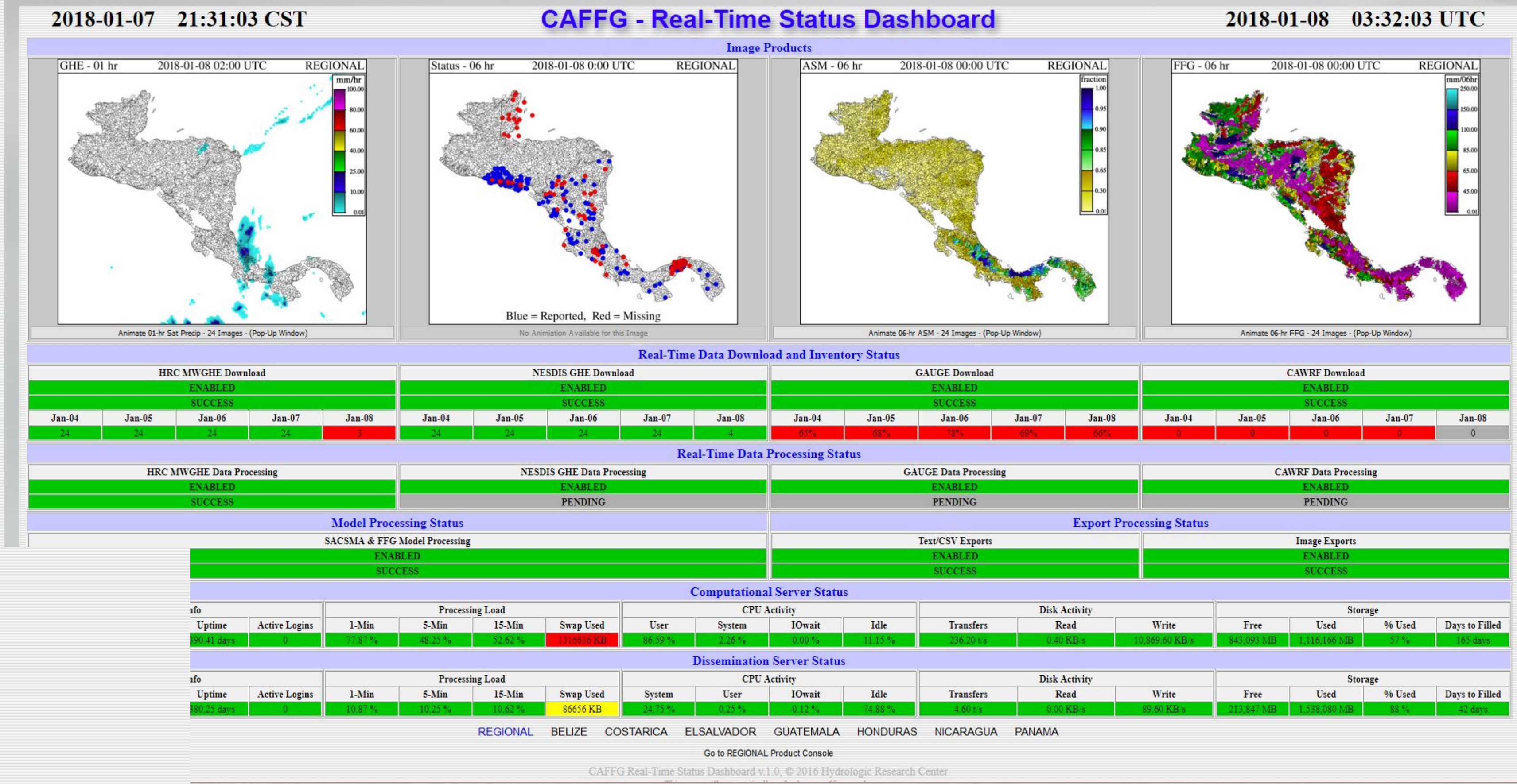
CSI(>0)=0.18

https://cds.imn.ac.cr/CAFFG/index.php



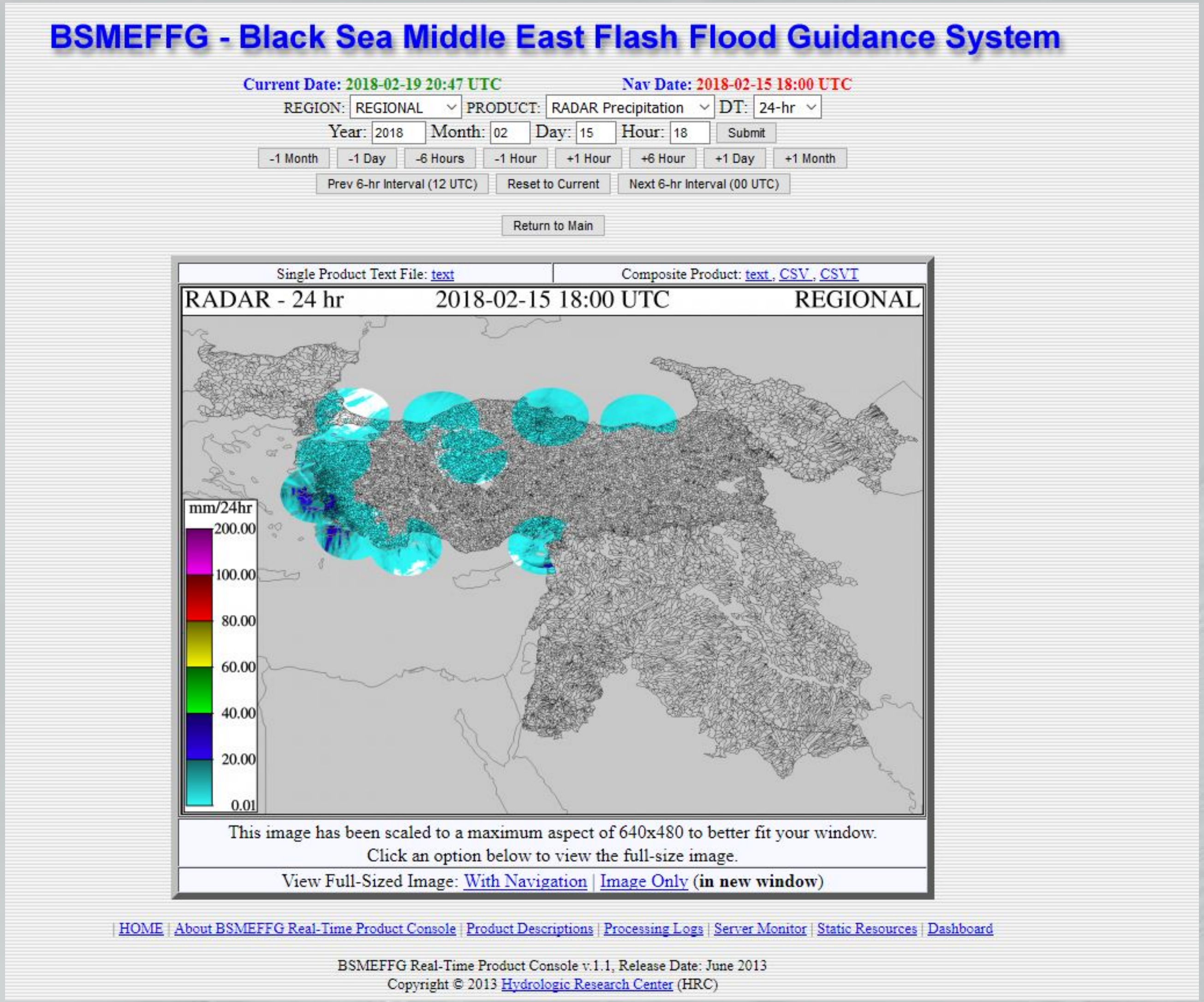


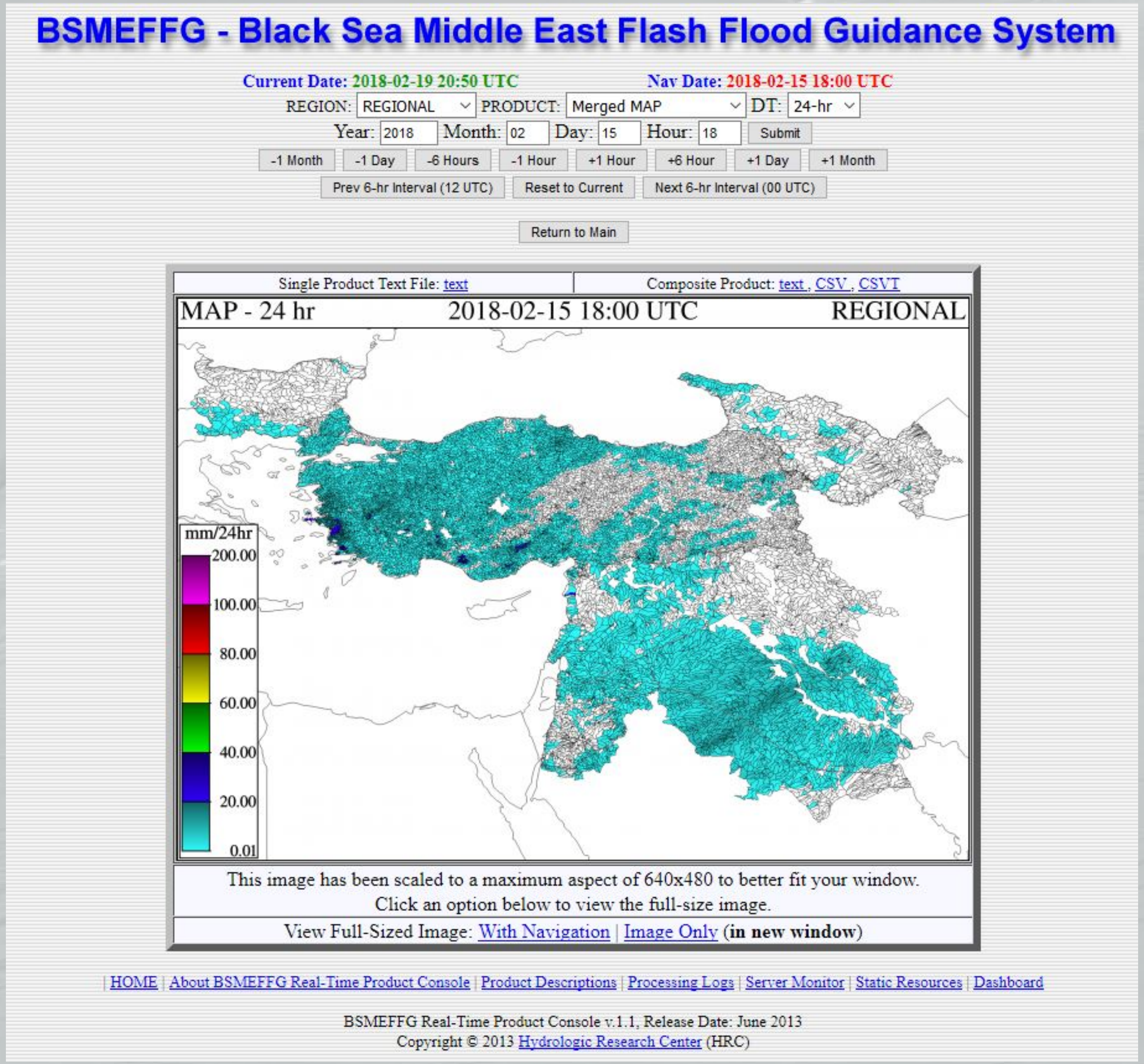




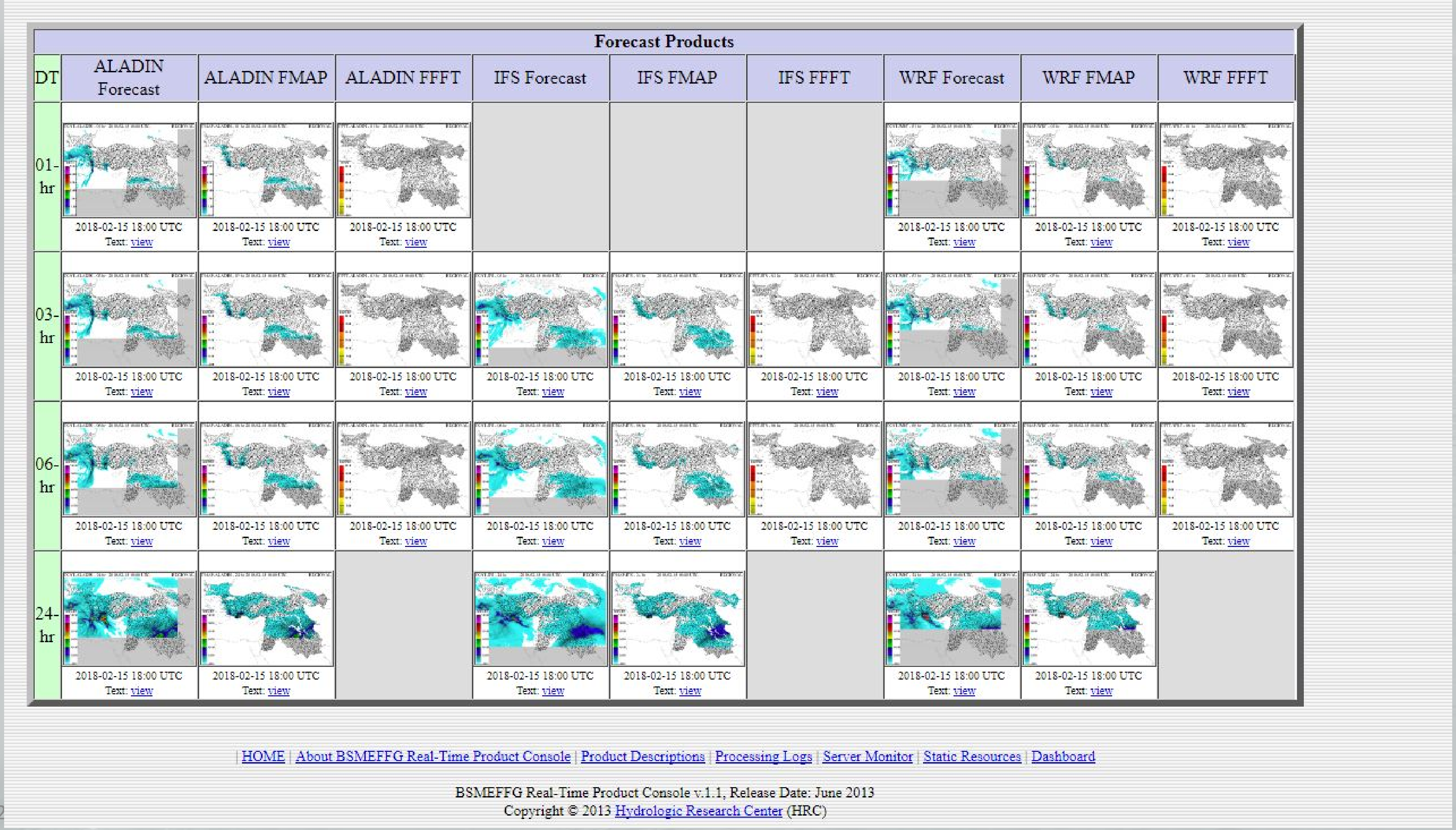
https://cds.imn.ac.cr/CAFFG_DASHBOARD/index.php?region=0

Use of Radar Data

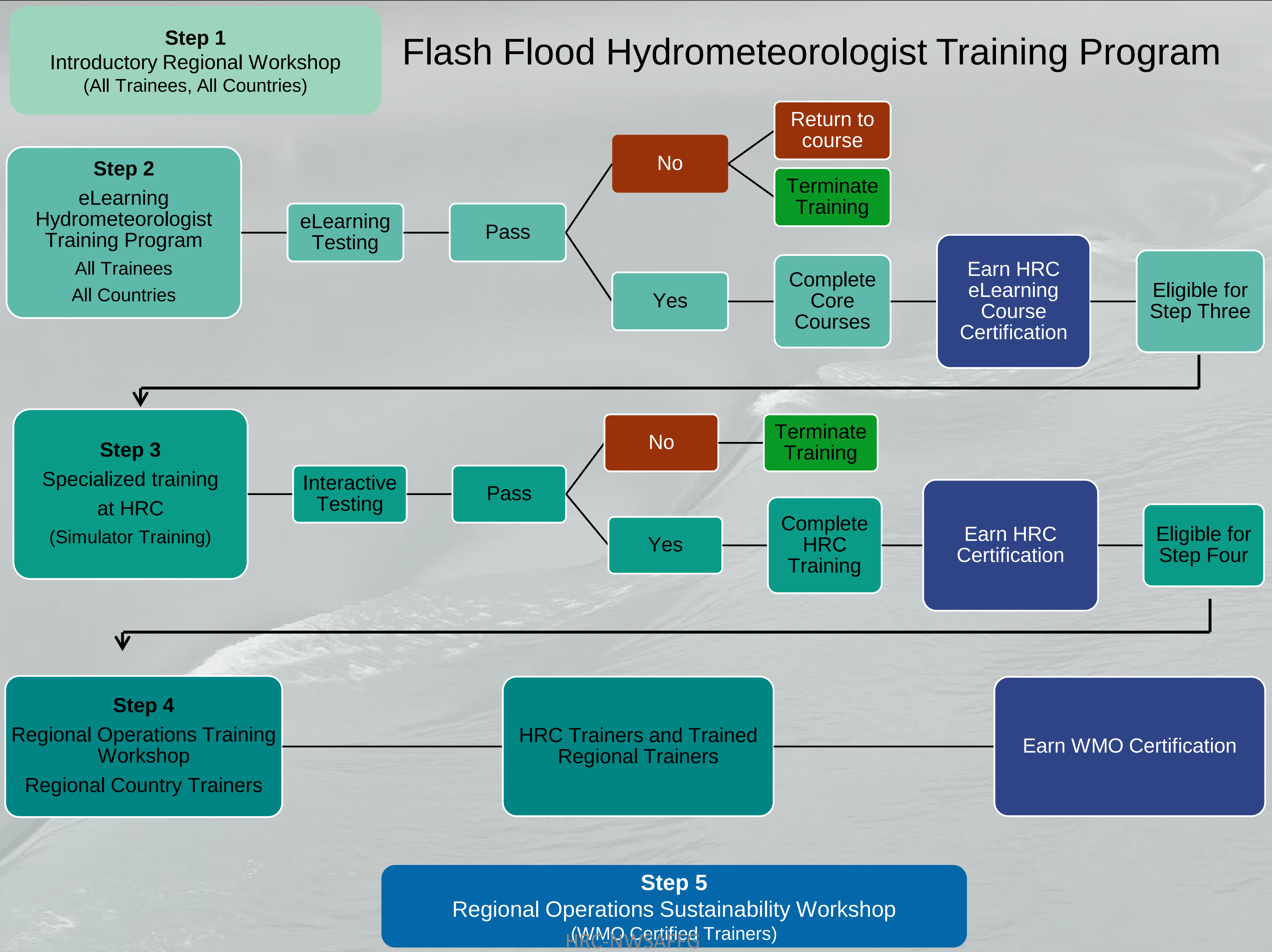




Multi-Mesoscale Model Ensemble Console



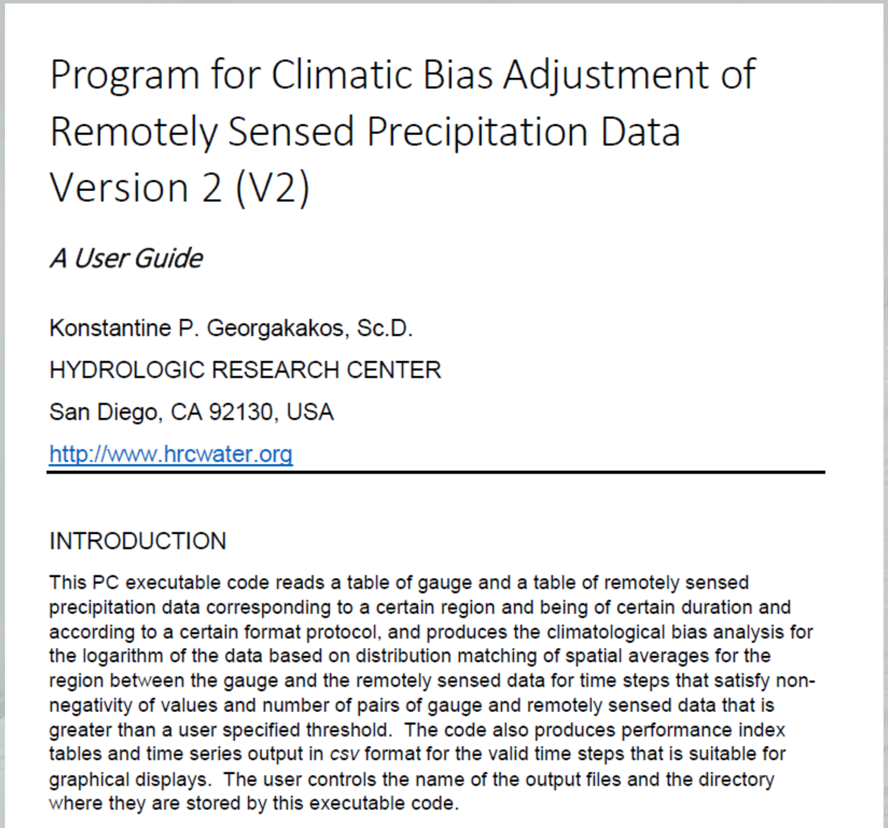
Flash Flood Hydrometeorologist Training Program



Hands-on Training Activities

Case Studies with System and Simulator

HRC Stand-Alone Software Distributed to Trainees for Validation and Sensitivity Analysis



Program for Climatic Bias Adjustment of Remotely Sensed Precipitation Data Version 2 (V2)

A User Guide

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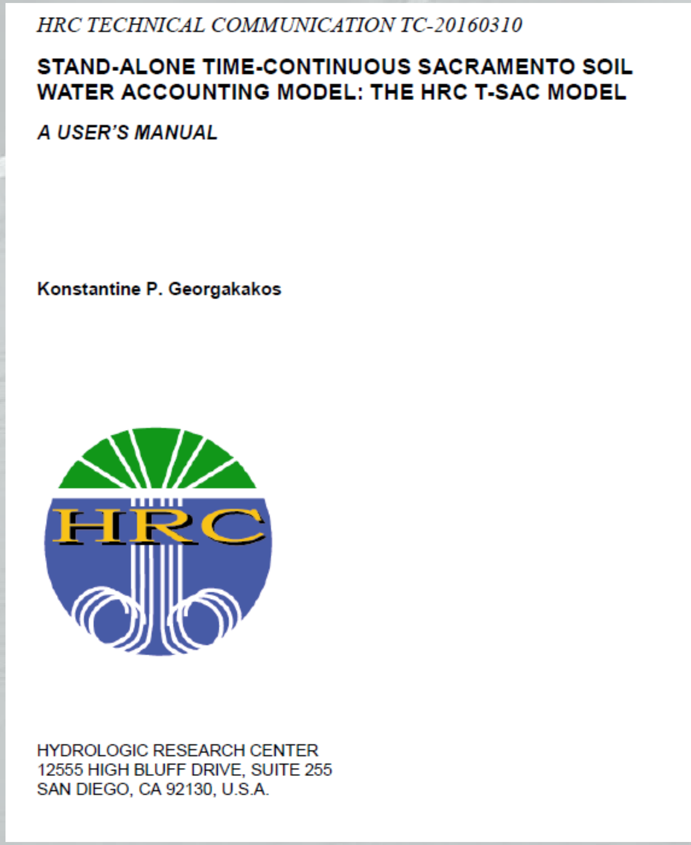
http://www.hrcwater.org

INTRODUCTION

This PC executable code reads a table of gauge and a table of remotely sensed precipitation data corresponding to a certain region and being of certain duration and according to a certain format protocol, and produces the climatological bias analysis for the logarithm of the data based on distribution matching of spatial averages for the region between the gauge and the remotely sensed data for time steps that satisfy non-negativity of values and number of pairs of gauge and remotely sensed data that is greater than a user specified threshold. The code also produces performance index tables and time series output in *csv* format for the valid time steps that is suitable for graphical displays. The user controls the name of the output files and the directory where they are stored by this executable code.



HRC TECHNICAL COMMUNICATION TC-20160310

STAND-ALONE TIME-CONTINUOUS SACRAMENTO SOIL WATER ACCOUNTING MODEL: THE HRC T-SAC MODEL

A USER'S MANUAL

Konstantine P. Georgakakos

HRC

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SAN DIEGO, CA 92130, U.S.A.

Verification and Validation Activities

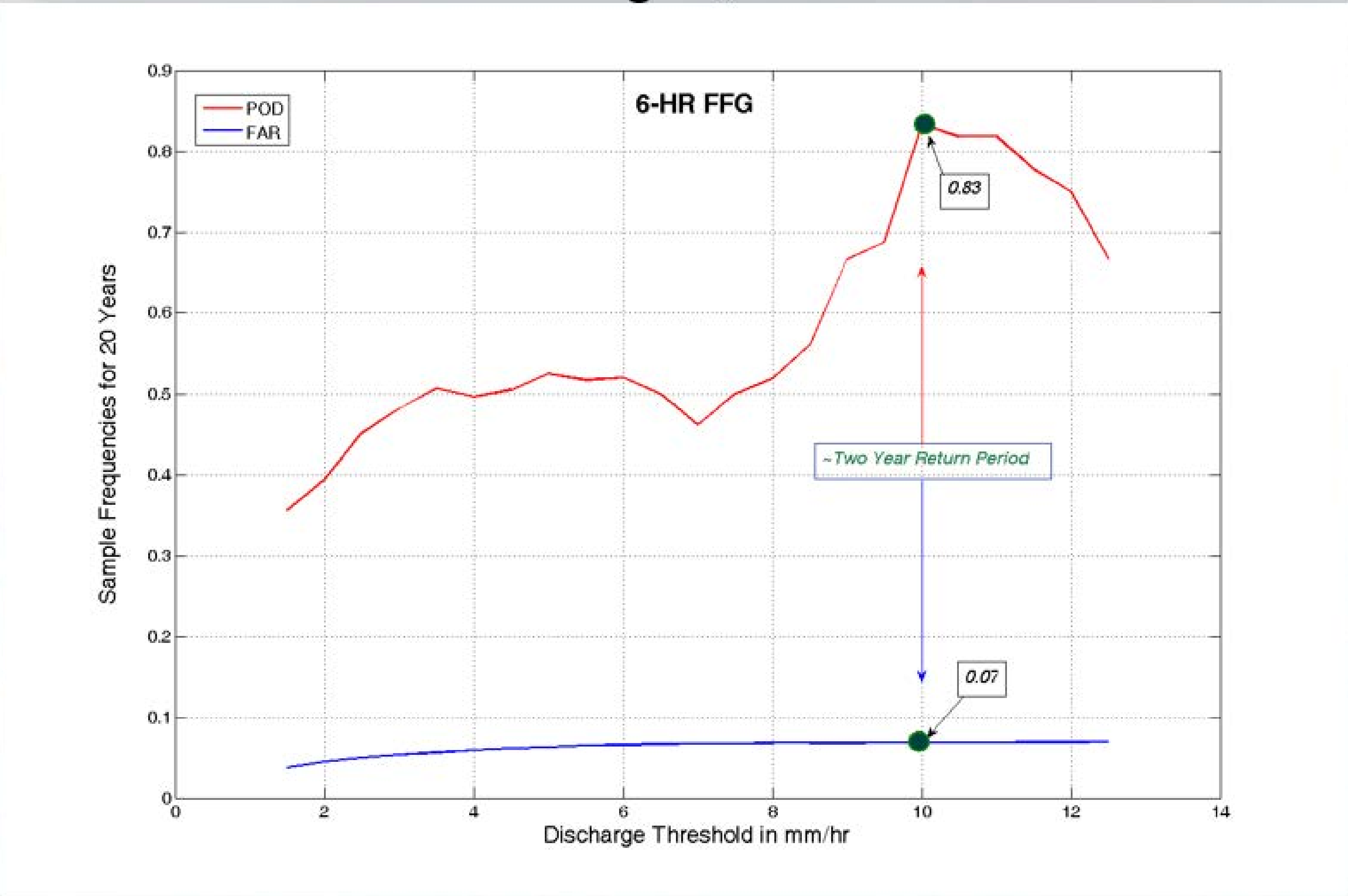
QPE Validation SARFFG

DJF	MWGHE: BEFORE	MWGHE: AFTER	GHE: BEFORE	GHE: AFTER
Res Mean	0.5 mm/d	0.03 mm/d	0.8 mm/d	0.12 mm/d
Obs Mean	1.7	1.7	1.9	1.9
Res St Dev	2.7	2.9	3.2	3.4
Obs St Dev	3.3	3.3	3.6	3.6

JJA	MWGHE: BEFORE	MWGHE: AFTER	GHE: BEFORE	GHE: AFTER
Res Mean	2.4 mm/d	0.06 mm/d	2.4 mm/d	0.17 mm/d
Obs Mean	3.2	3.2	4.0	4.0
Res St Dev	3.4	3.2	3.7	4.1
Obs St Dev	4.6	4.6	4.8	4.8

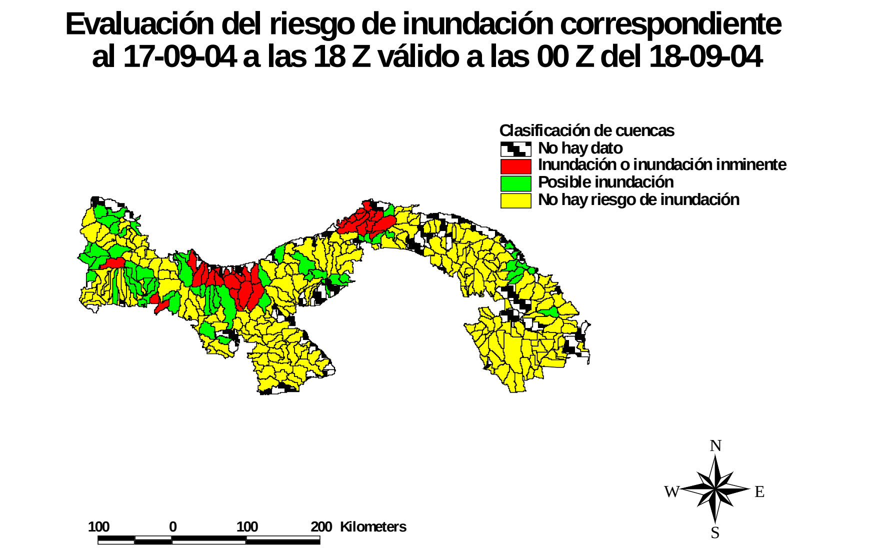
Single Data-Rich Basin Validation

Rio Chagres, Panama



Example of Warning Validation

System operators from Costa Rica and El Salvador were in daily communication with Country Agencies to receive community information regarding local flooding



Flooding in the Panama Canal verified by local TV news. Flooding time at the airport was reported at approximately 9 p.m. local time.

3-Hourly FF Threat (*adjst*):
Hits: 57% (*63 – 100%*)
False: 30% (*0 - 21%*)
Misses: 13% (*0 - 16%*)

Second Example of Warning Validation - Turkey

cy (AFAD) and Turkish State Meteorological Service (TSMS). TSMS reports flash floods

gency table.

		Observations (Flash Flood Reports: TSMS+DSI+Press)		
		Y	N	Σ
Bulletin (21 May2012 - 17 June 2013)	Y	43 (a)	25(b)	68
	N	18 (DSI) (c)	306(d)	324
	Σ	61	331	392

Figure-105 Contingency table of FF Bulletins for Turkey

Hit Rate (POD): a / (a+c)	0.70
False Alarm Ratio(FAR): b / (a+b)	0.36
False Alarm Rate (POFD): b/(b+d)	0.07
Threat Score: a / (a+b+c)	0.50

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

FFG Development Team at HRC

Konstantine Georgakakos – Managing Technical Director/Hydrometeorology/Measurement Uncertainty

Robert Jubach - General Management/Disaster Risk Reduction

Jason Sperfslage - IT Systems Engineering

Theresa Modrick - Hydrometeorological Modeling

Eylon Shamir – Soil Water and Snow Models

Cris Spencer – IT Engineering/Programming

Randall Banks – IT Engineering/Programming

Zhengyang Cheng – Fluvial Hydraulics and Flood Routing

Rochelle Graham – Education and Training/Links to Disaster Management