

Coping with Forecast Uncertainty for Water Management and Public Warning *A Global Perspective*

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HRC - AMS07 Intl. Session
1/12/2007

Motivation

- Floods and Flash Floods are very significant disasters globally, **BUT** there are no discernible trends for loss reduction

Highest average mortality rate
(Deaths/People Affected)

Forecast/Warning-Response
System deficiencies
Human development in flood
prone areas

- Increased population exerts increased demand on available water resources

Requires:
Increased efficiency of water
resources management using
foresight



Global Perspective

THE PROBLEM:

Lack of Operational Hydrometeorological Forecasts and Warnings over large areas of the world

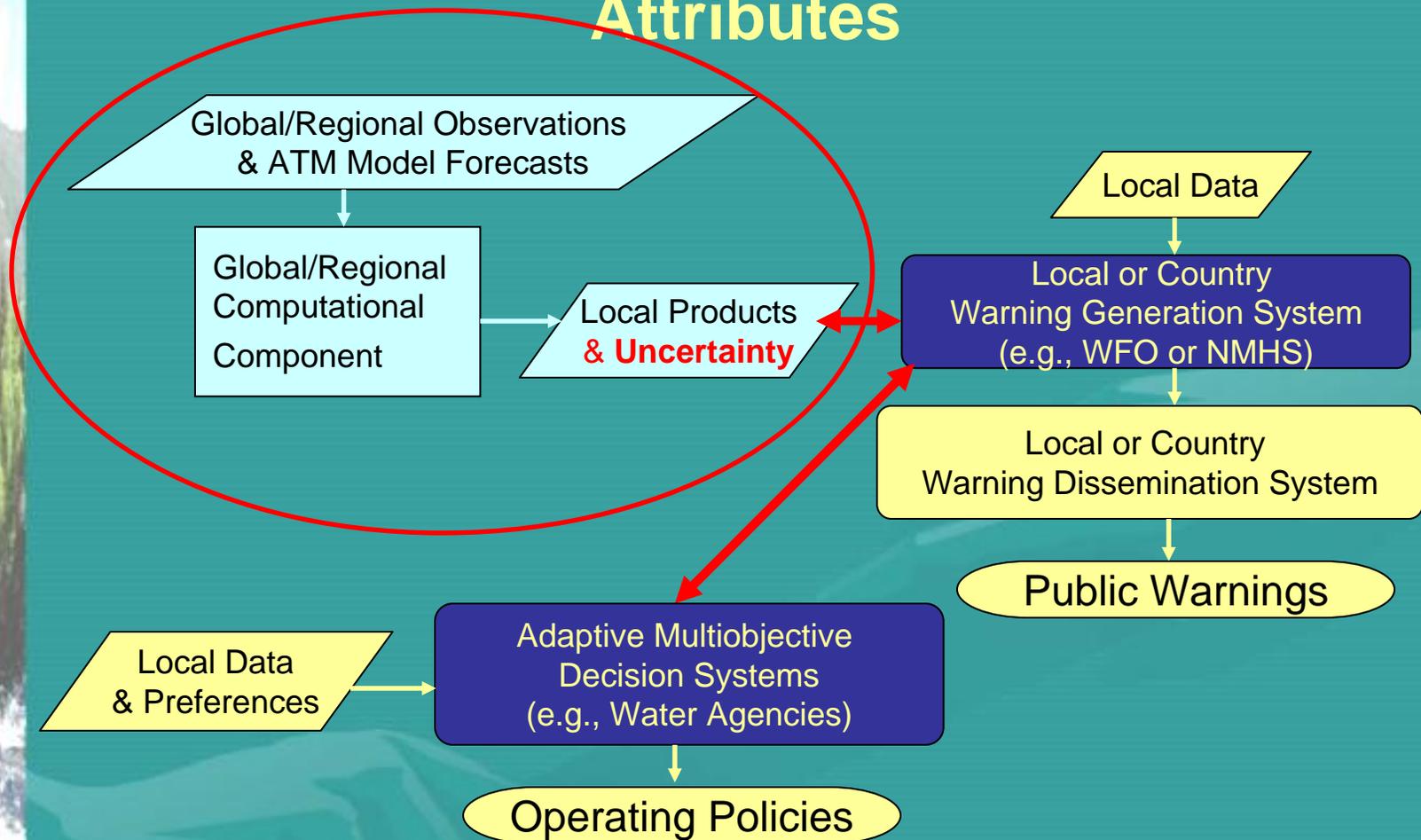
- Flash floods
- Regionally coordinated water resources management

REMEDIES BASED ON:

Global and regional hydrometeorological systems at sites with resources for data retrieval, technical expertise and maintenance

- Real time and off-line global databases
- Powerful computing environments
- Internet and other communication networks for dissemination and training

Global/Regional Operational Systems Attributes



1. Decisions are made with multiple datasets and under uncertainty
2. There is a need to modify the products of the global/regional system locally and have capability for estimating consequences to local variables of interest



REQUIREMENTS FOR OPERATIONAL UTILITY

1. Characterization of uncertainty
2. Ability for Local or Country NMHS intervention and real time adjustment (warnings)
3. Decision support under well-characterized uncertainty (water resources management)
4. Regional training programs



The Need to Cope with Forecast Uncertainty

Forecasts are inherently uncertain

Decisions to issue warnings and water management policies are made under uncertainty

Hydrometeorological forecasts for smaller regions based on global data carry considerable uncertainty

Uncertainty comes in a variety of forms, from biases to a variety of distributions of forecast residuals, and it is time dependent (not a trivial problem)

Scale Dependence of Uncertainty

$E[R_Q] < 0.5$ for $A > 150$ km² - Parametric Uncertainty

$E[R_Q] < 0.5$ for $A > 750$ km² - Parametric and Rainfall Uncertainty

Diagnostic Measure

$$R_Q = \frac{Q_{90} - Q_{10}}{2Q_{50}}$$

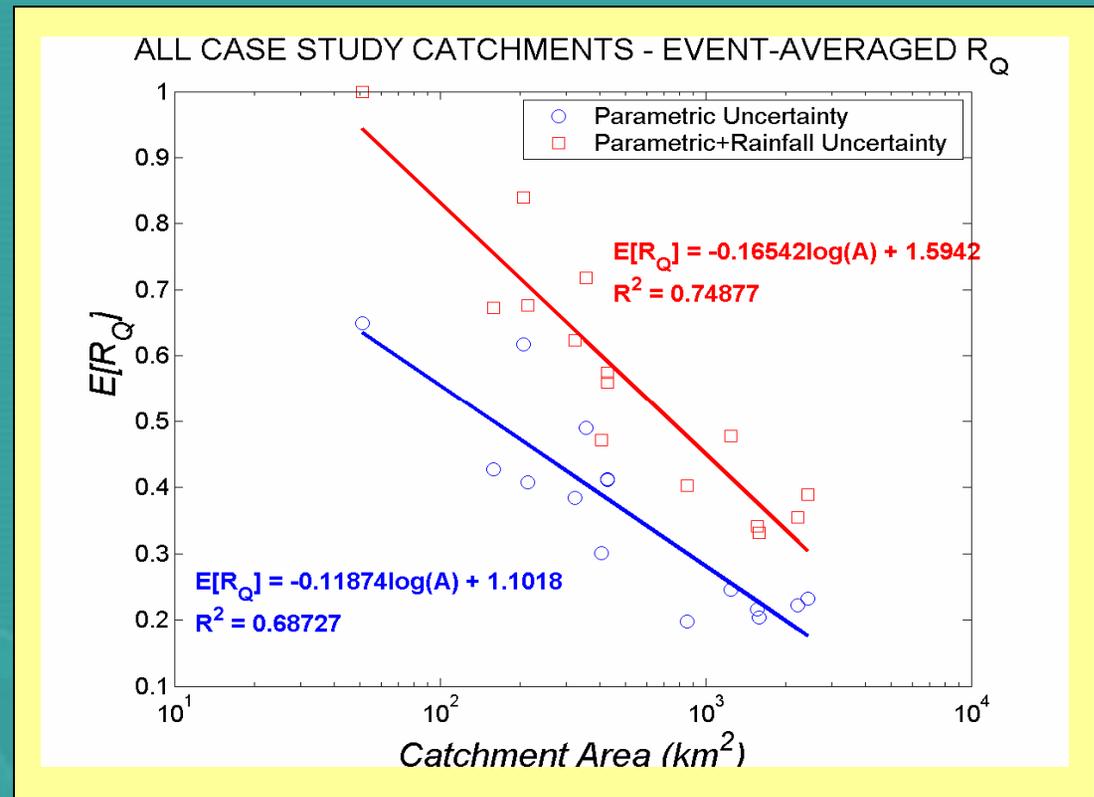
Q_{90} : 90th percentile flow

Q_{10} : 10th percentile flow

Q_{50} : Median flow

Note: At time for which
 R_Q is maximum for
each event

$E[R_Q]$: Average over all
events in each basin

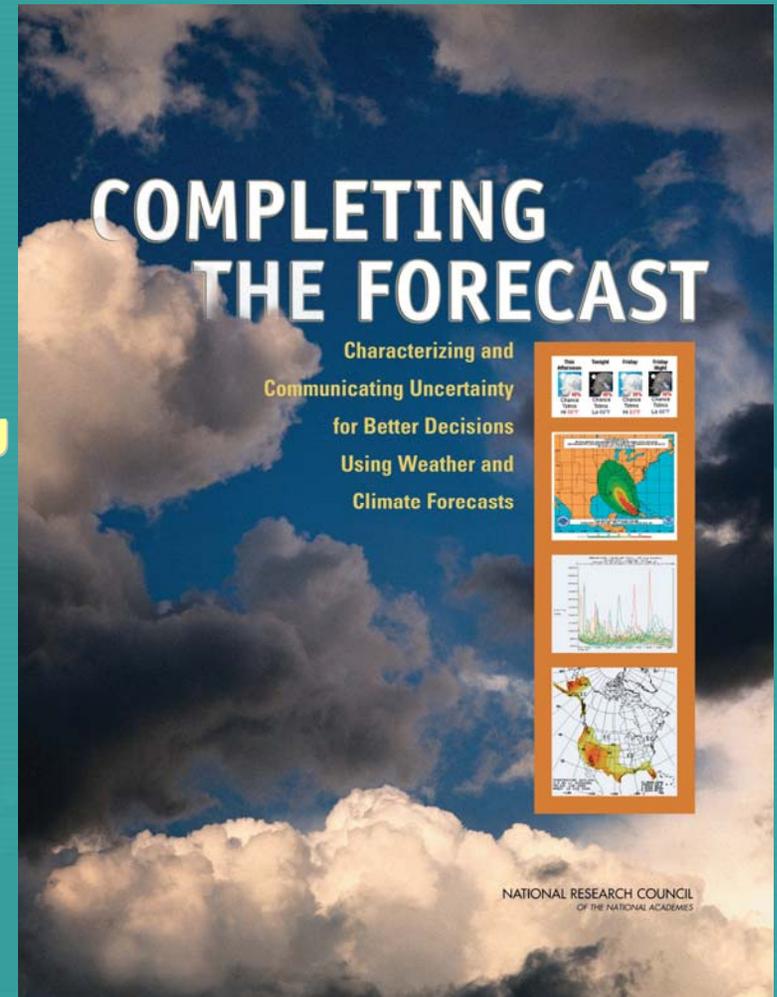


Results from Distributed Model Intercomparison Project

Completing the Forecast

Characterizing and Communicating Uncertainty for Better Decisions Using Weather and Climate Forecasts

AMS Town Hall Meeting
Wed 17 Jan 9:00-10:00am



Board on Atmospheric Sciences and Climate

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

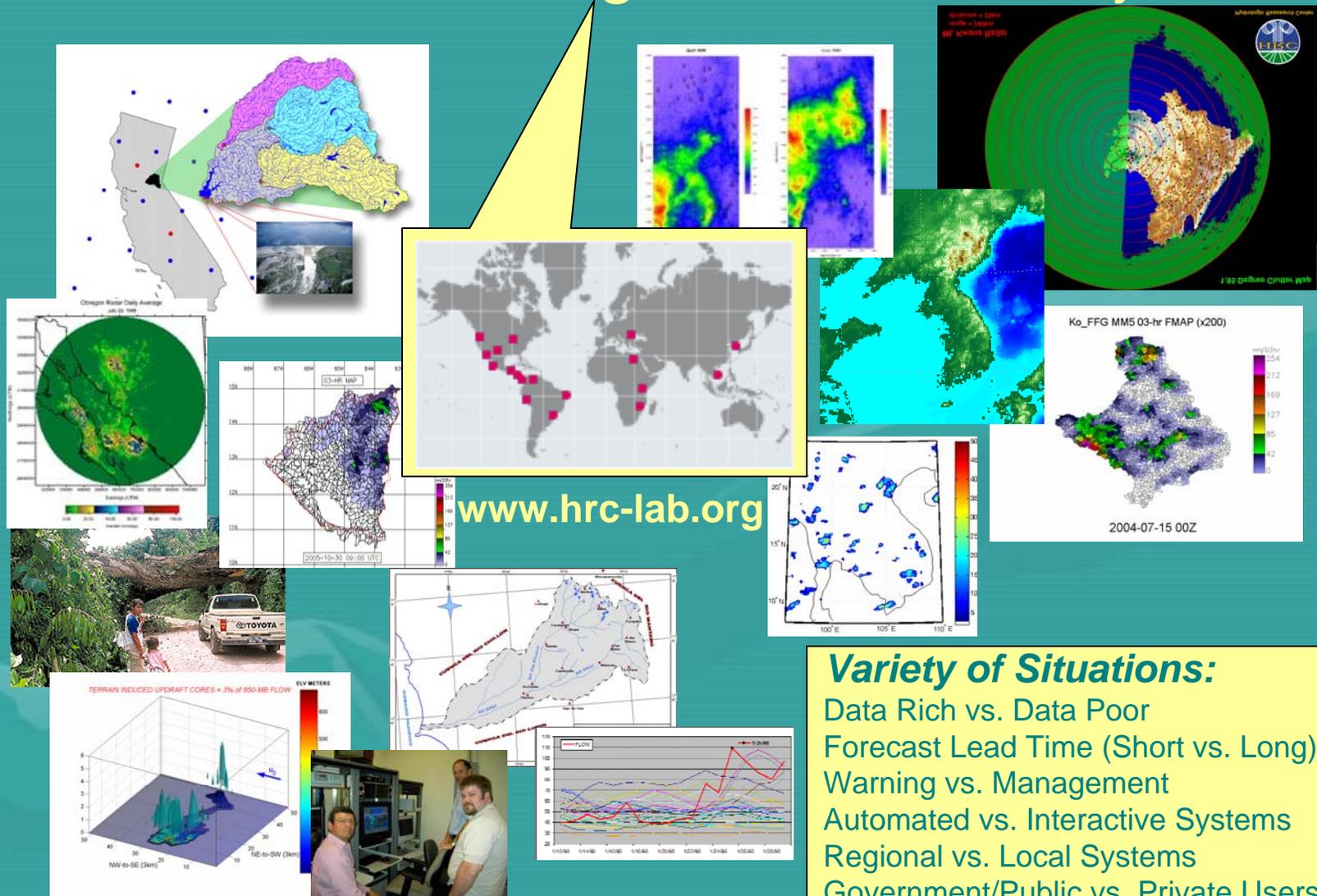
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NRC REPORT RECOMMENDATIONS

1. Develop and maintain the ability to produce objective uncertainty information from the global to the regional scale.
2. Expand verification of system uncertainty products and make this information easily available to all users in near real time
3. Maintain strong links with the Users of the products

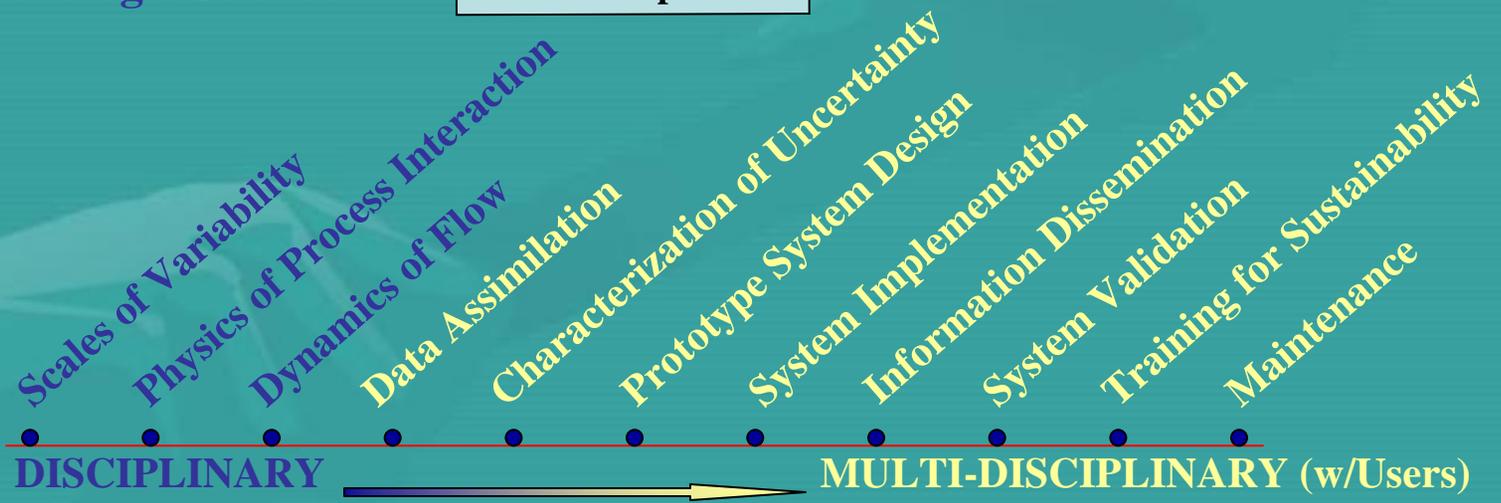
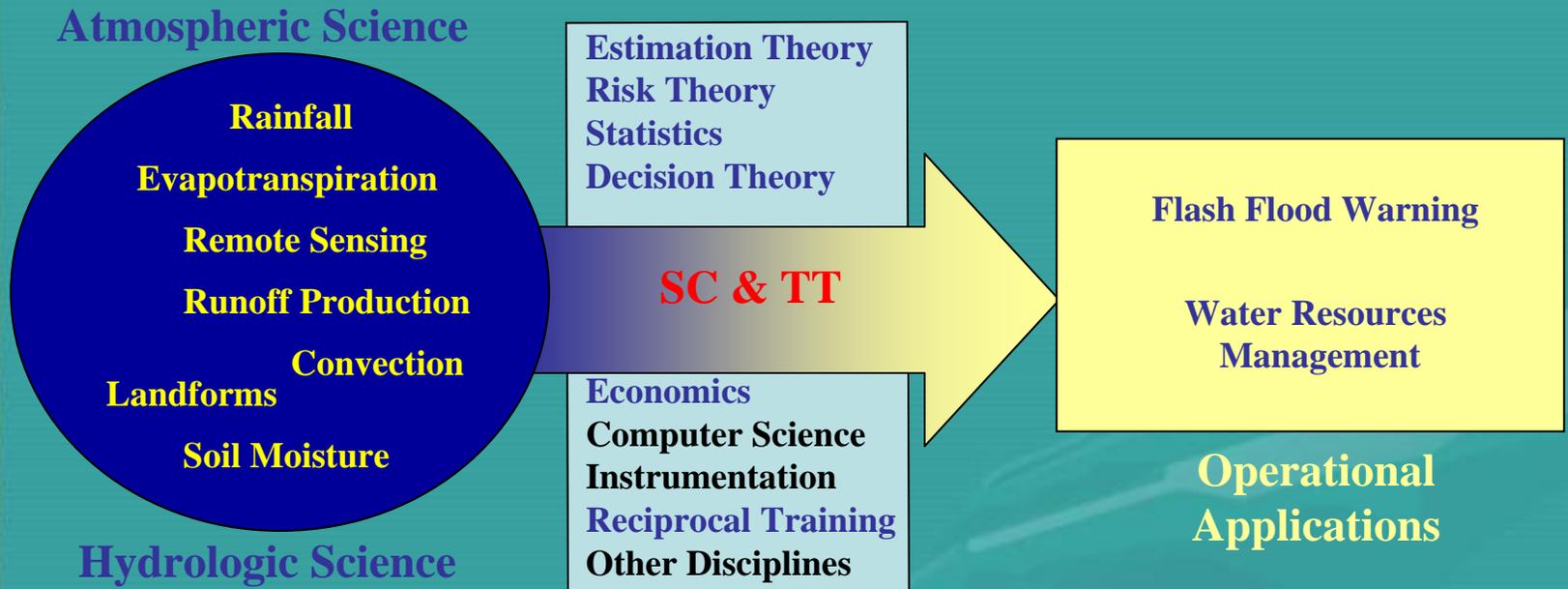
Examples from the HRC Worldwide Involvement in Regional Water Projects



www.hrc-lab.org

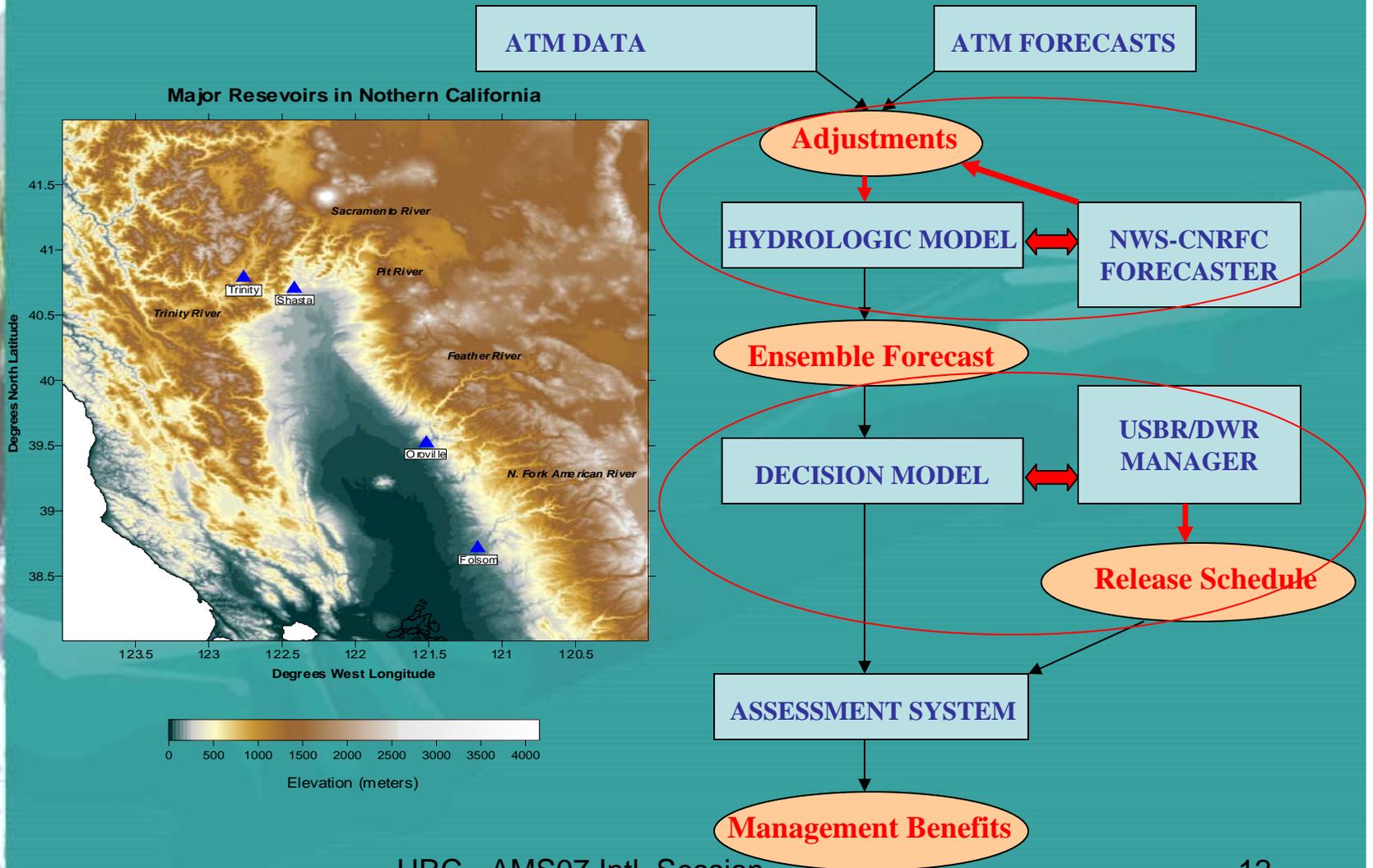
Variety of Situations:
 Data Rich vs. Data Poor
 Forecast Lead Time (Short vs. Long)
 Warning vs. Management
 Automated vs. Interactive Systems
 Regional vs. Local Systems
 Government/Public vs. Private Users

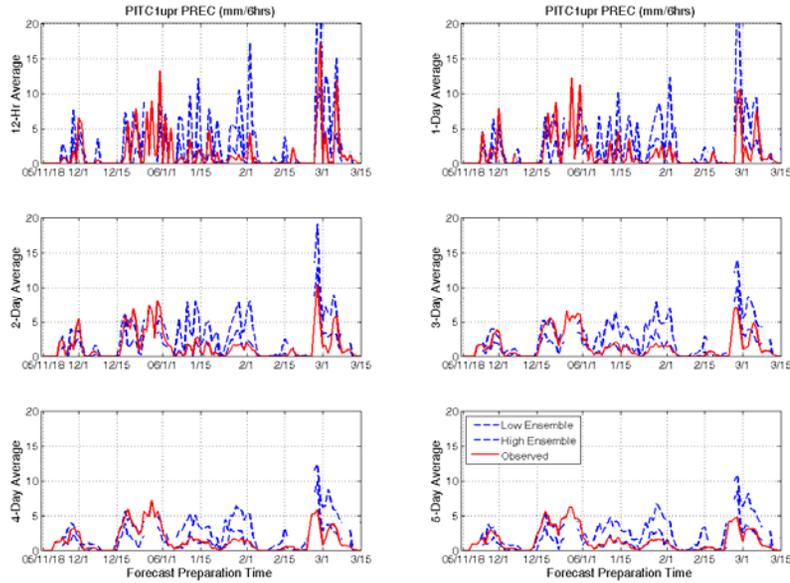
HRC Approach to Science Cooperation and Technology Transfer



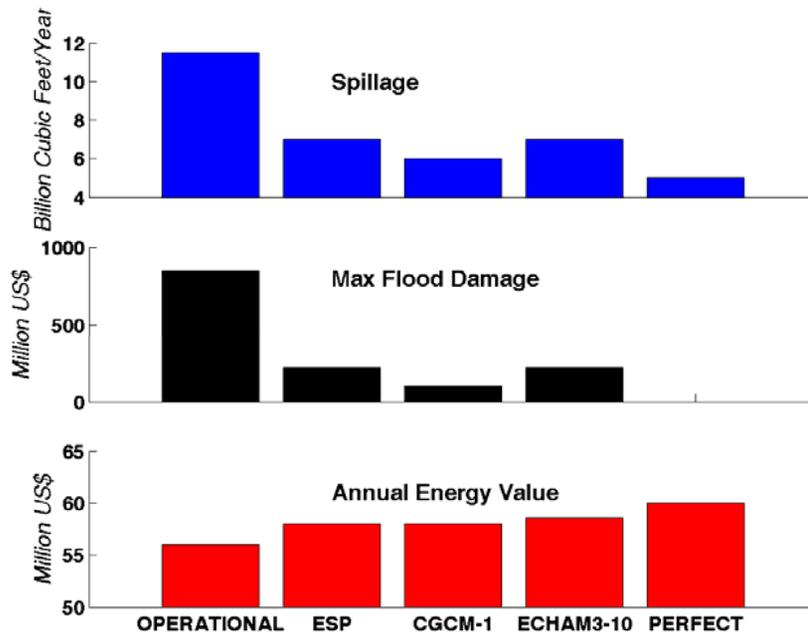
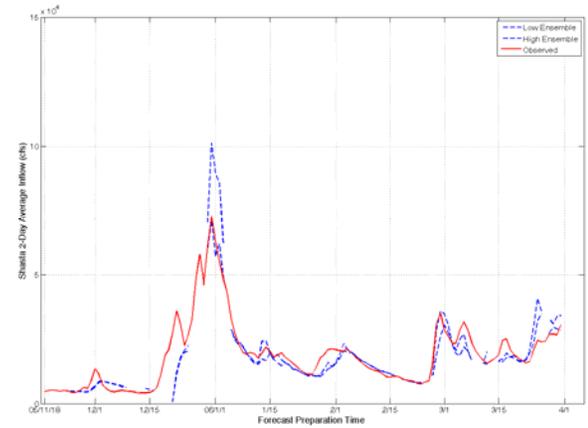
REGIONAL MANAGEMENT EXAMPLE

Integrated Forecast and Reservoir Management (INFORM)
Demonstration for Northern California Water Resources



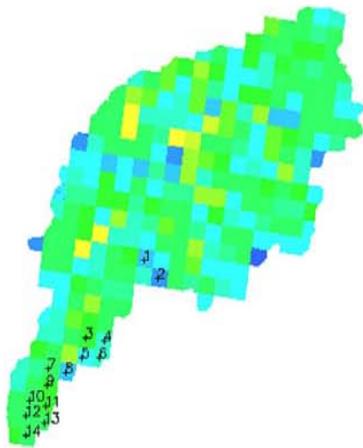


INFORM PHASE I RESULTS

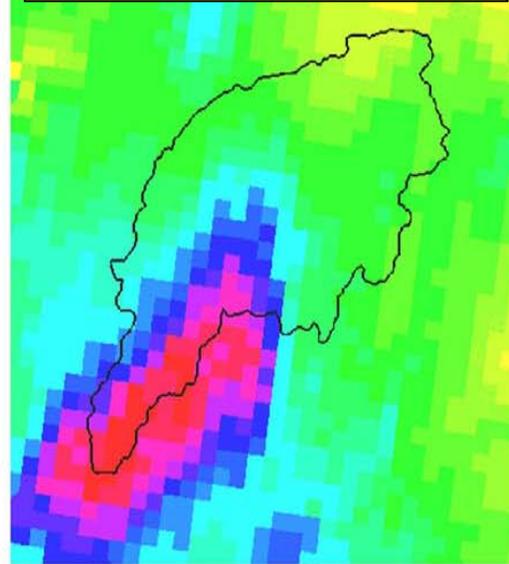


Regional Warning Example Flash Flood Guidance

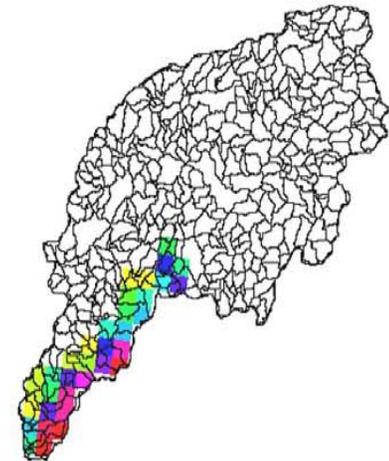
Flash Flood Guidance (in/hr)



Gridded Rainfall (in/hr)



Excess Flooding (in/hr)



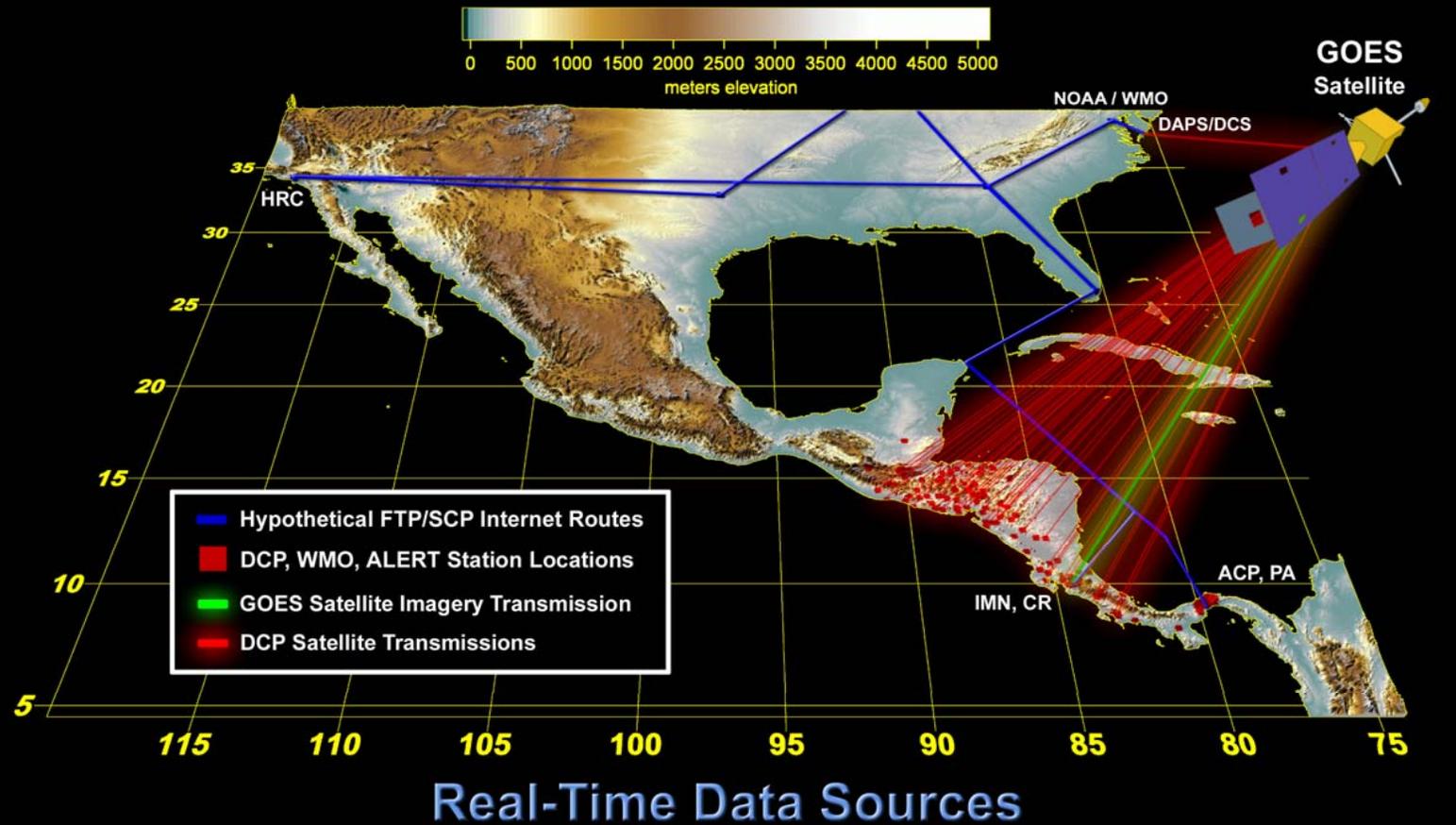
Flash Flood Guidance (FFG): The amount of actual rainfall of a given duration, required to generate bankfull flows at the outlet of a small basin.

Flash Floods are a True Hydrometeorological Problem

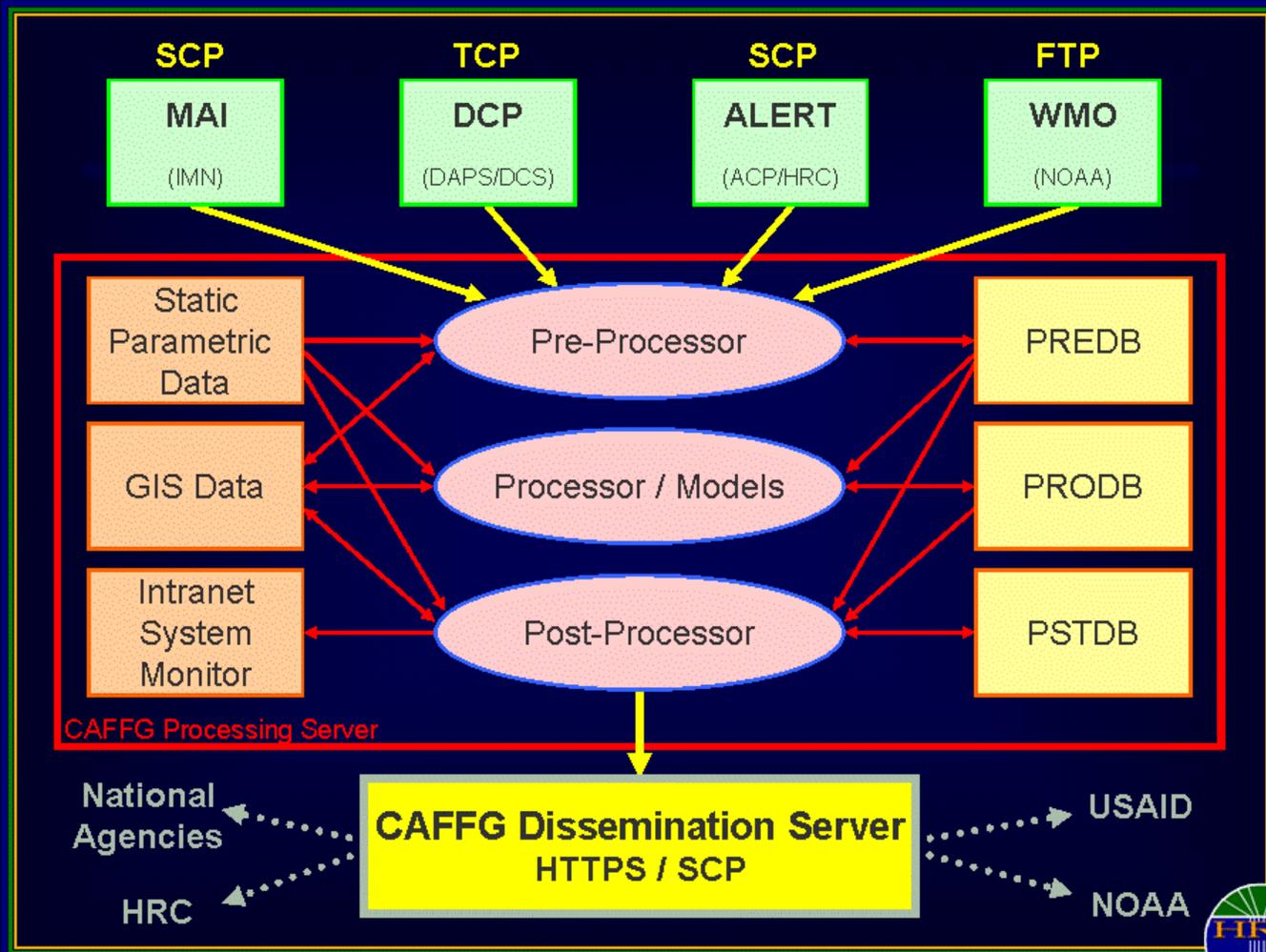
REGIONAL WARNING EXAMPLE

CAFFG

Central America Flash Flood Guidance



CAFFG PROCESSING



7

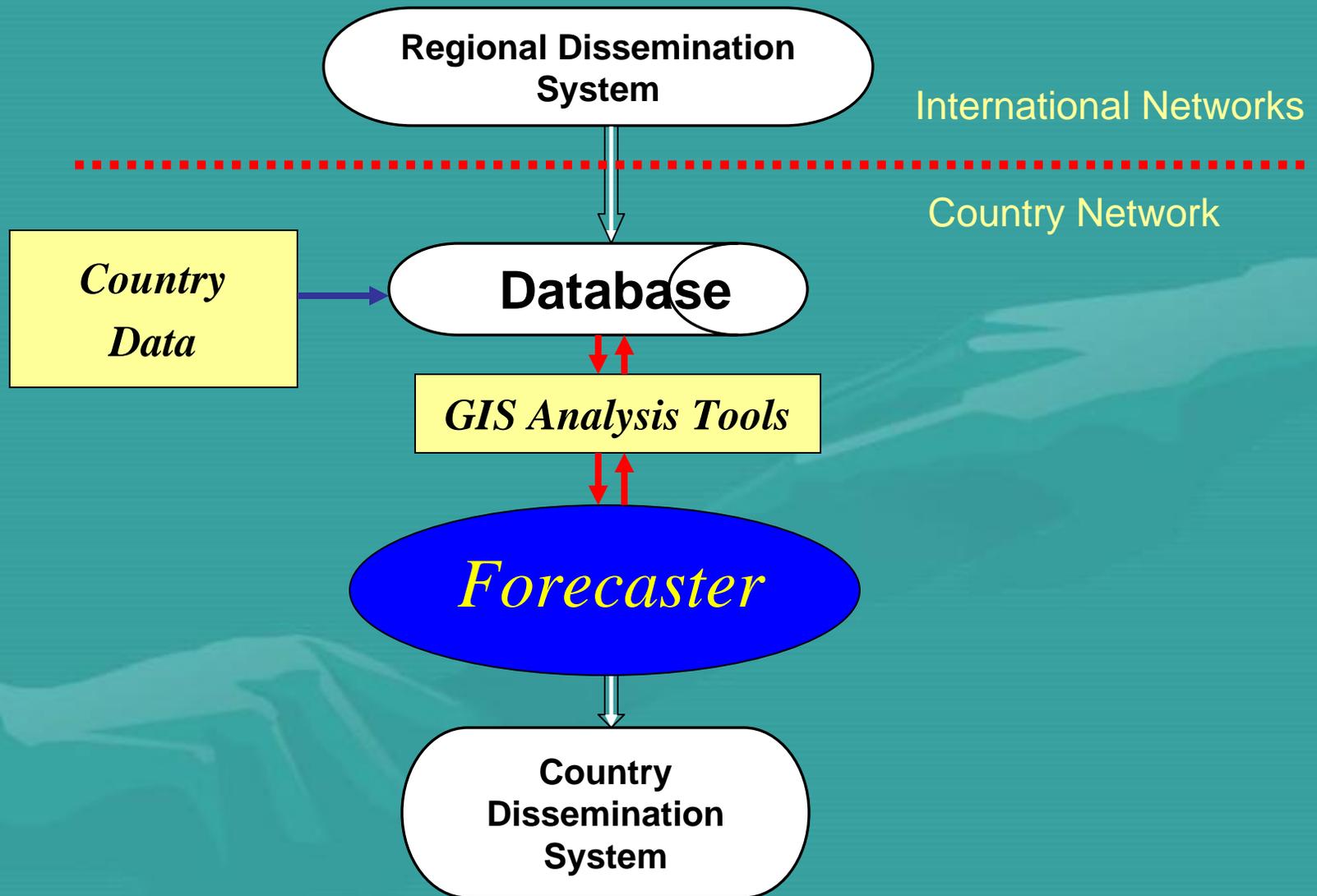
August 4, 2004

Mr. Jason Sperflage

Hydrologic Research Center



Country System for Warnings





Training and Cooperation

Training:

System Technical Basis

Maintenance

Interpretation of Guidance Products

*Hands-on training of personnel who will operate the system
Workshops for NMHS and Response Agency personnel*

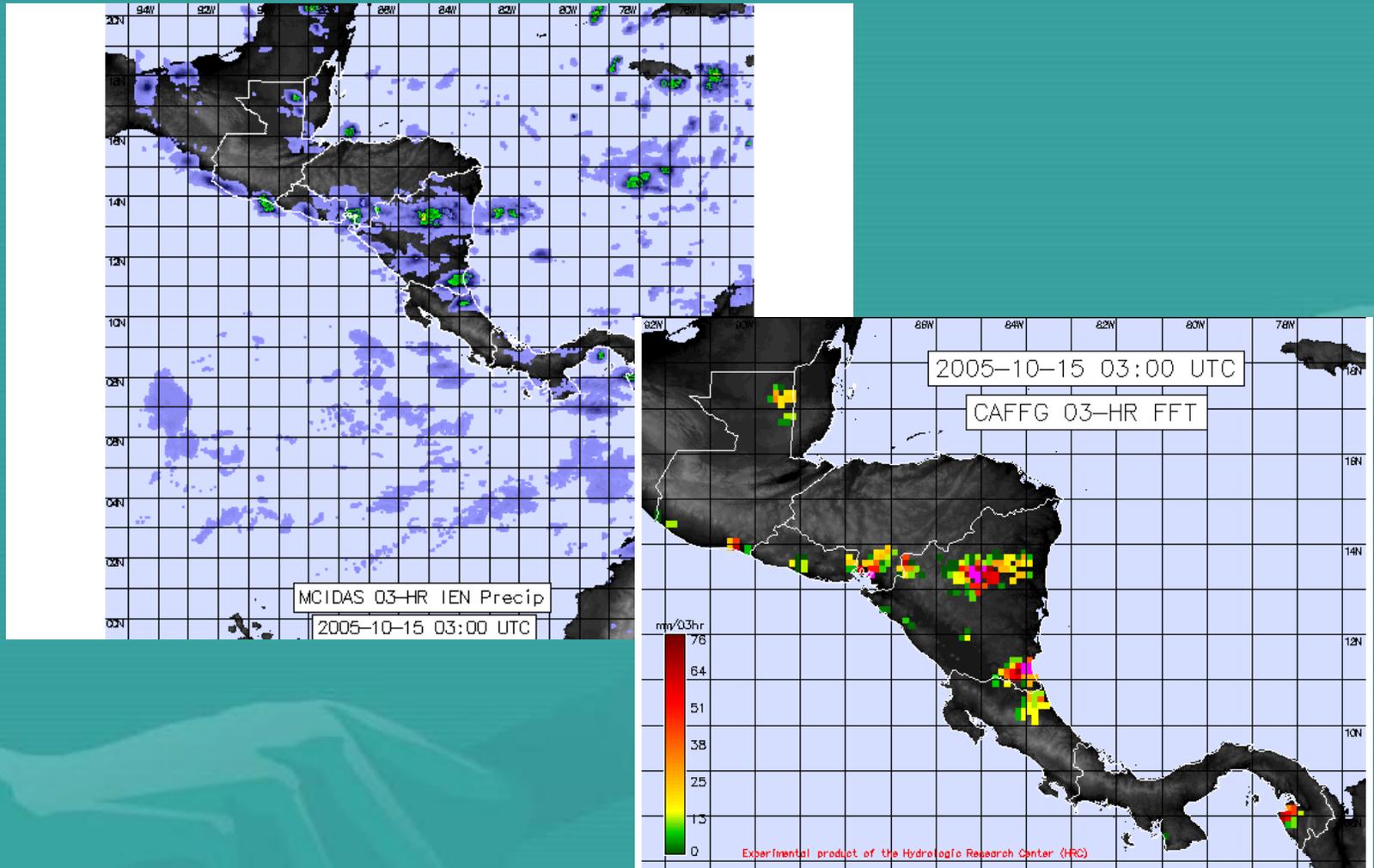
Cooperation:

Assist NHMSs to develop protocol for issuing warnings based on flash flood guidance

Assist NMHSs and Response Agencies to develop protocol for dissemination, receipt and interpretation of warning information to appropriate users within countries

Assist NMHSs and Response Agencies to develop evaluation plans for system utility

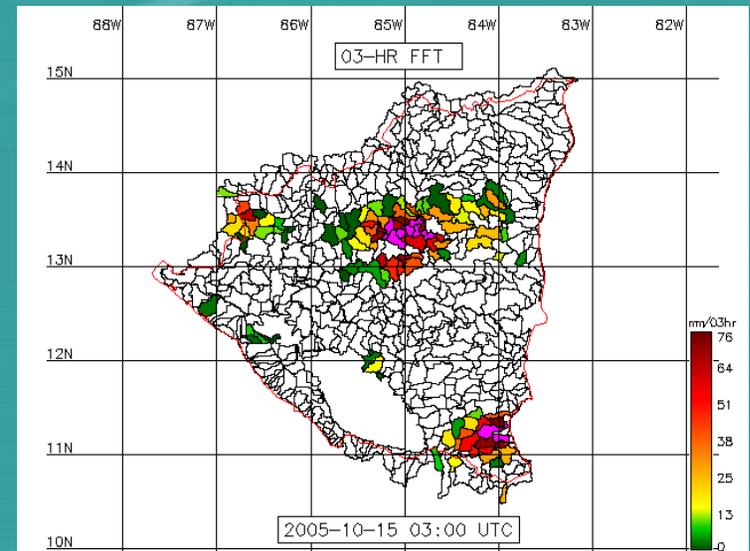
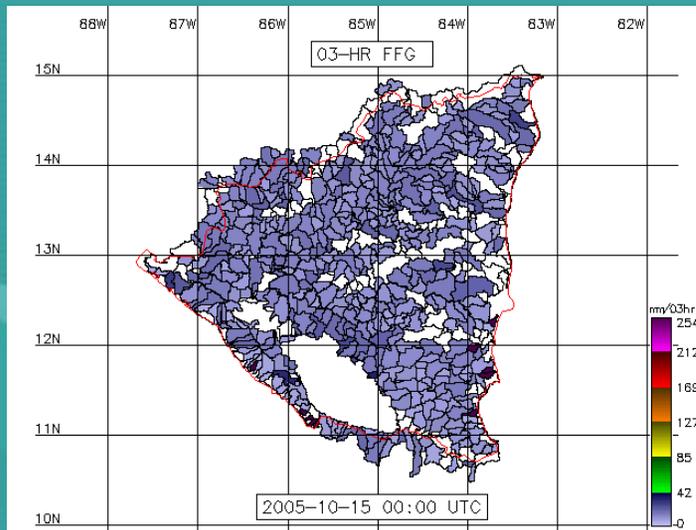
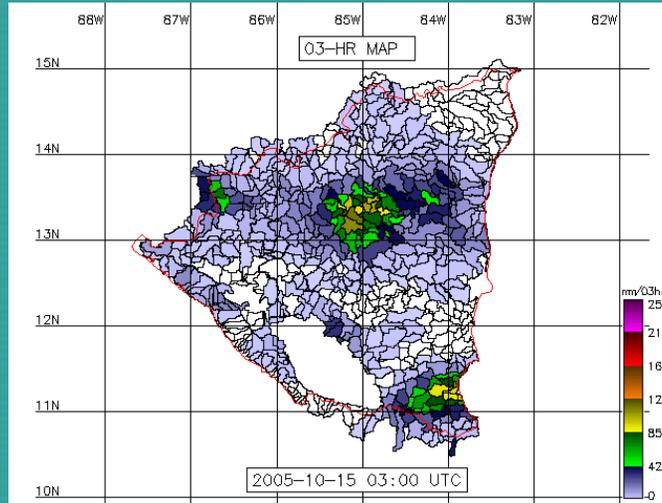
CAFFG PUBLIC PRODUCTS



<http://www.hrc-lab.org>

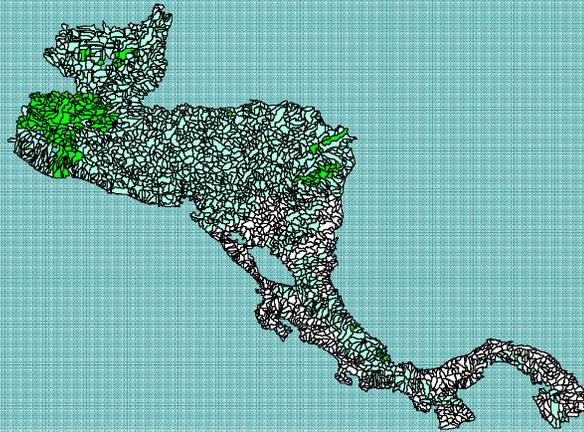
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CAFFG NMHS PRODUCTS



CAFFG PRODUCTS

**Central America Flash Flood Guidance System
3-Hour MAP - Date: 15 May 2004 0000Z**



3-HOUR MAP

White	0 - 0.01 (mm)
Light Green	0.01 - 37.5 (mm/ 3-hr)
Green	37.5 - 75 (mm/3-hr)
Yellow	75 - 112.5 (mm/3-hr)
Orange	112.5 -150 (mm/3-hr)
Red	150 - 187.5 (mm/3-hr)
Purple	187.5 - 228 (mm/3-hr)

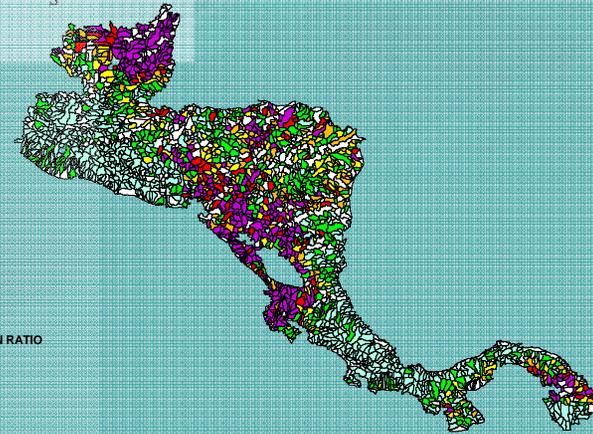
**Central America Flash Flood Guidance System
6-Hourly Soil Moisture - Date: 15 May 2004 0000Z**



6-HOUR SOIL SATURATION RATIO

White	0 - 0.33
Light Blue	0.33 - 0.5
Medium Blue	0.5 - 0.64
Dark Blue	0.64 - 0.77
Very Dark Blue	0.77 - 0.88
Black	0.88 - 1

**Central America Flash Flood Guidance System
3-Hour FFG - Date: 15 May 2004 0000Z**



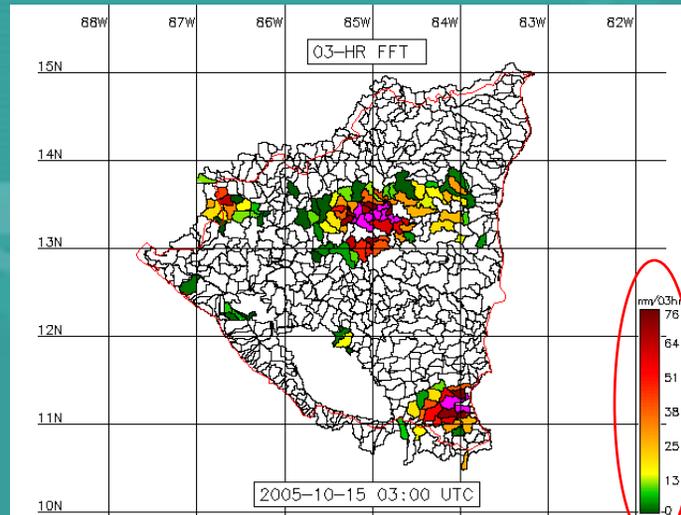
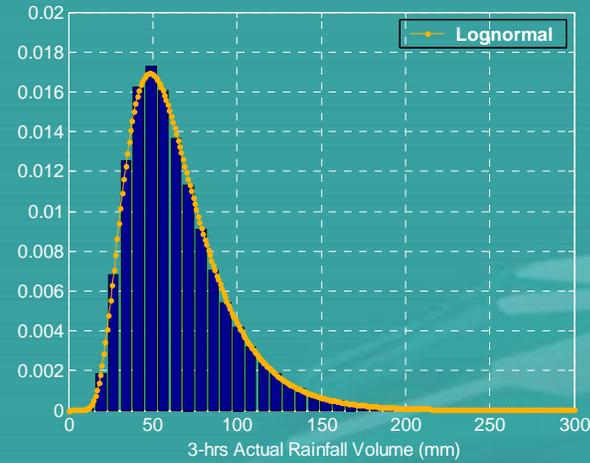
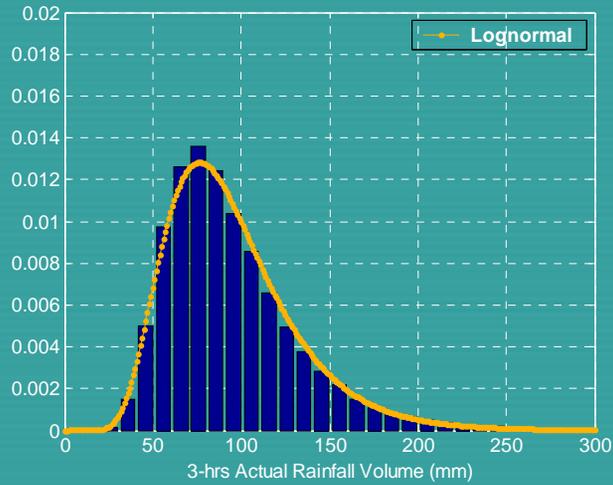
3HR FFG COLOR TABLE

White	0 - 0.01 (mm)
Light Green	0.01 - 37.5 (mm/ 3-hr)
Green	37.5 - 75 (mm/3-hr)
Yellow	75 - 112.5 (mm/3-hr)
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FFG Uncertainty

3-hr Flash Flood Guidance Probability Density Function



+ User input

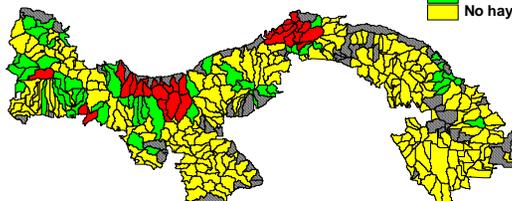
CAFFG INITIAL VALIDATION

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

Evaluación del riesgo de inundación correspondiente al 17-09-04 a las 18 Z válido a las 00 Z del 18-09-04

Clasificación de cuencas

- No hay dato
- Inundación o inundación inminente
- Posible inundación
- No hay riesgo de inundación



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



Total of 28 requests:
Hits: 18 (64%)
False Alarms: 9 (32%)
Misses: 1 (4%)

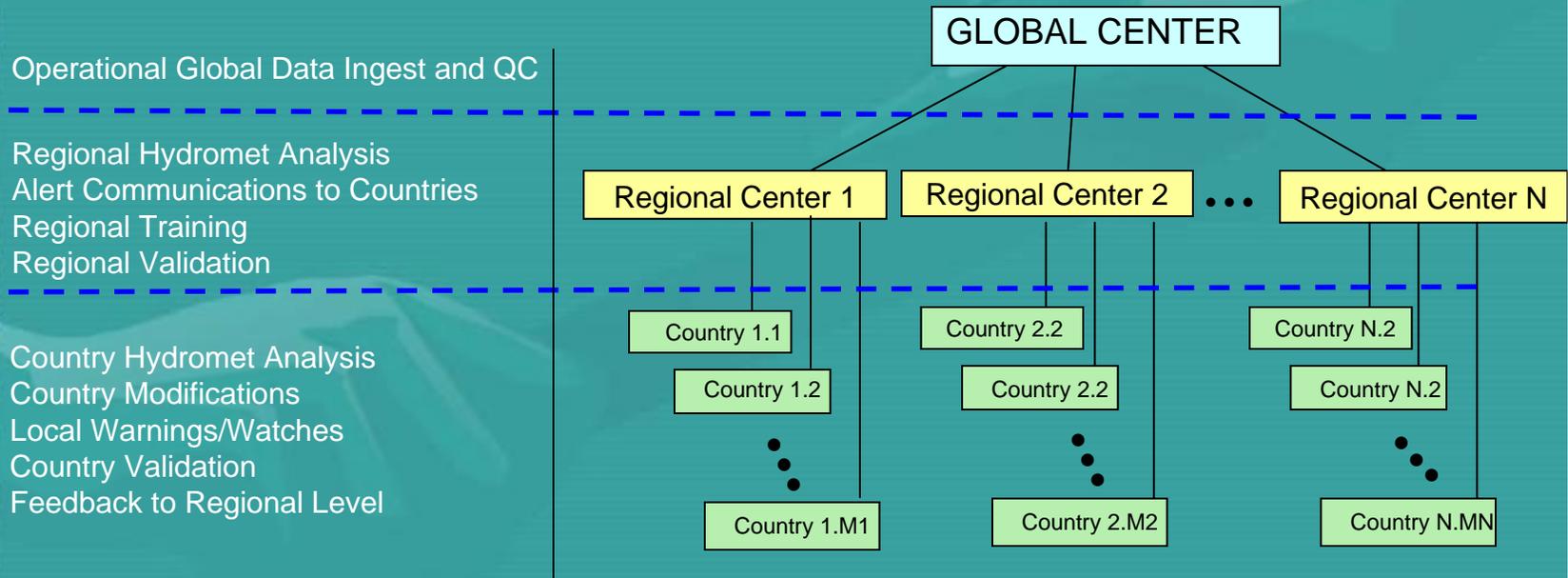
HRC Concept for Global Flash Flood Forecasting and Warning

Primary Target:

Developing Countries with no resources to develop flash flood warning capability

Funding Consortium:

Private and Public Donors





Summary of Important Points

1. Characterize and produce uncertainty in all operational products
2. Create new operational warning process paradigms in developing countries using global products with capability for local data ingest and local adjustment
3. Develop effective approaches for validation and continuing improvement of operations, and associate products with validation statements
4. Establish international operational requirements for using sources of global forecasts and observations
5. Develop and educate of a viable user community for warning information and products.
6. Encourage the continuing cooperation and reciprocal training of forecasters and managers

Thank You

*HRC INFORM AND CAFFG Programs were
Funded by:*

**CALFED Bay Delta Authority
California Energy Commission
NOAA NWS (IAO, OHD)
NOAA CPO
US Bureau of Reclamation
US Agency for International Development / OFDA
and
Private Donations**

Additional Information:

<http://www.hrc-lab.org>