

# Flash Flood Guidance System On-going Enhancements

*Hydrologic Research Center, USA  
Technical Developer*

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# FFG System Enhancements

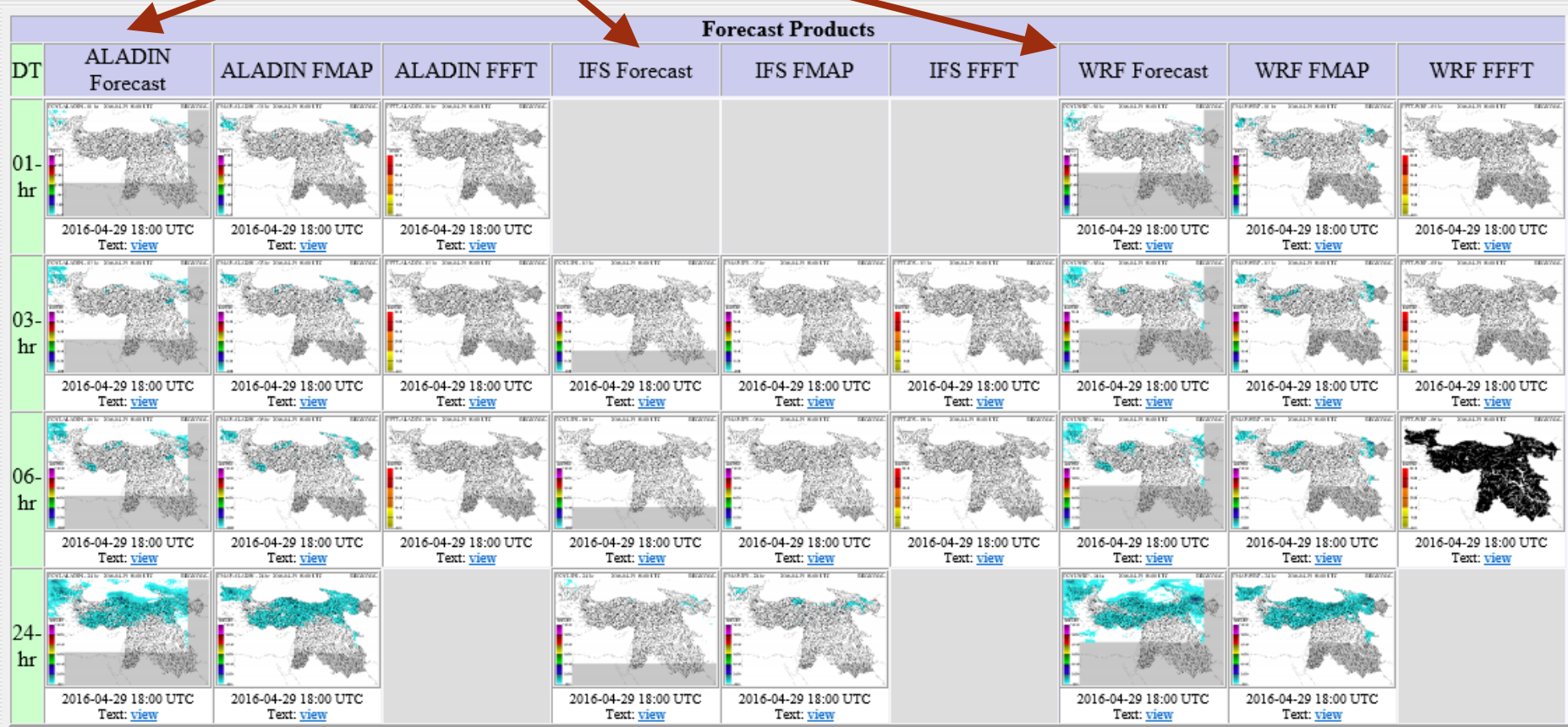
*The following enhancements are in various stages of development and implementation based on specific country needs, expressed interest, funding priorities and cooperation.*

- ❖ *Multi-model quantitative precipitation forecast (QPF) use within FFG systems*
- ❖ *Use of satellite inundation mapping and associated surface soil moisture observations to adjust FFGS soil water estimation.*
- ❖ *Landslide susceptibility and landslide occurrence prediction*
- ❖ *Urban Flash Flood Warning*
- ❖ *Riverine routing and discharge ensemble prediction*

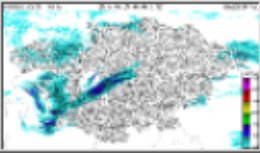
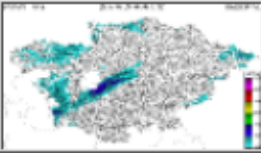

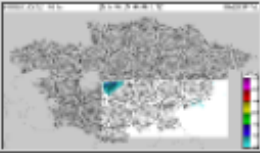


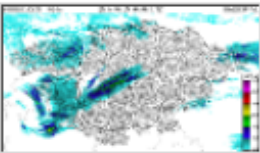
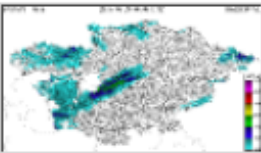
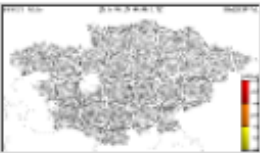
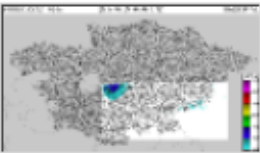
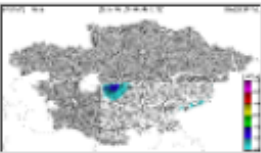

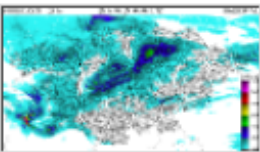
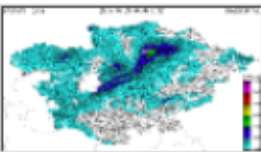
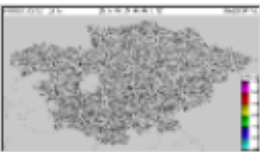
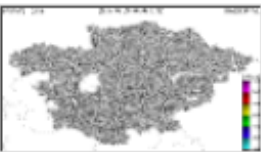
# Multi-model Quantitative Precipitation Forecasts (QPF) Use

*Example from the Black Sea Middle East (BSMEFFGS)*

*QPF from 3 operational NWP models available to forecasters*

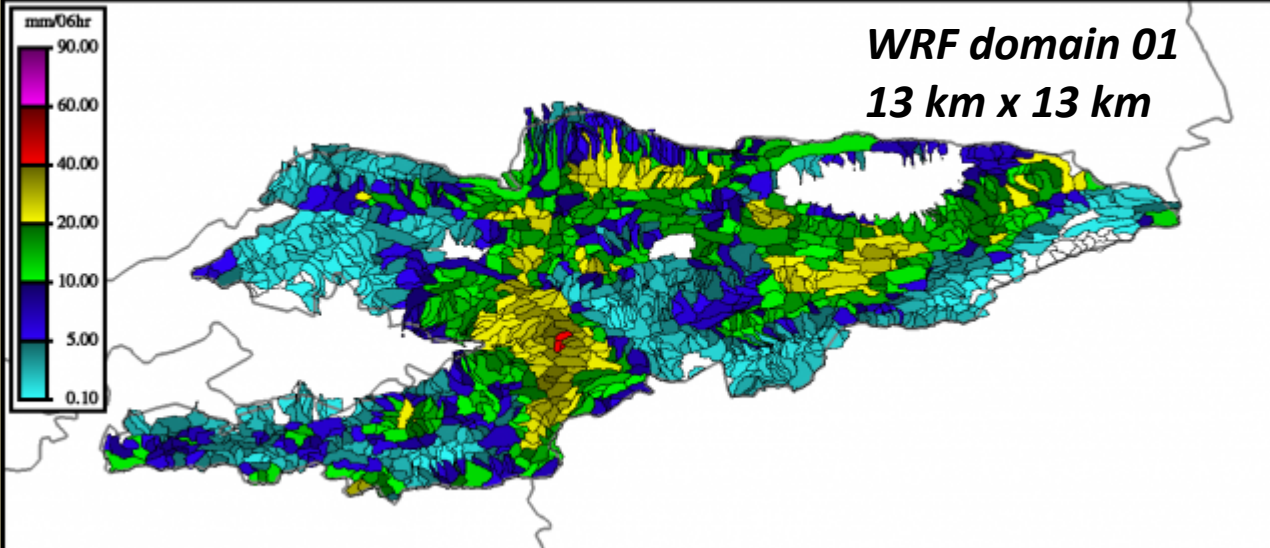


# Multi-model QPF Use in CARFFG System

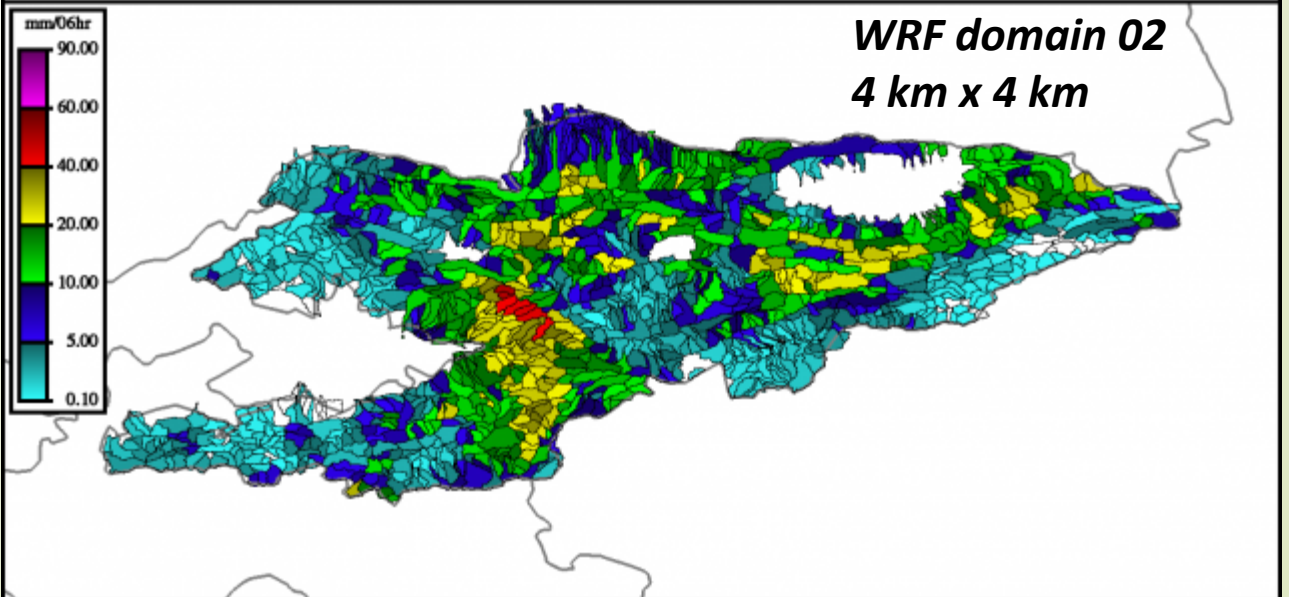
Forecast Products						
DT	WRF D01 Forecast	WRF D01 FMAP	WRF D01 FFFT	WRF D02 Forecast	WRF D02 FMAP	WRF D02 FFFT
01-hr						
03-hr	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>
06-hr	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>
24-hr	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>		 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	

# Multi-model QPF Use in CARFFG System

FMAP1 - 06 hr      2016-10-02 00:00 UTC      KYRGYZSTAN



FMAP2 - 06 hr      2016-10-02 00:00 UTC      KYRGYZSTAN



# Landslide Susceptibility

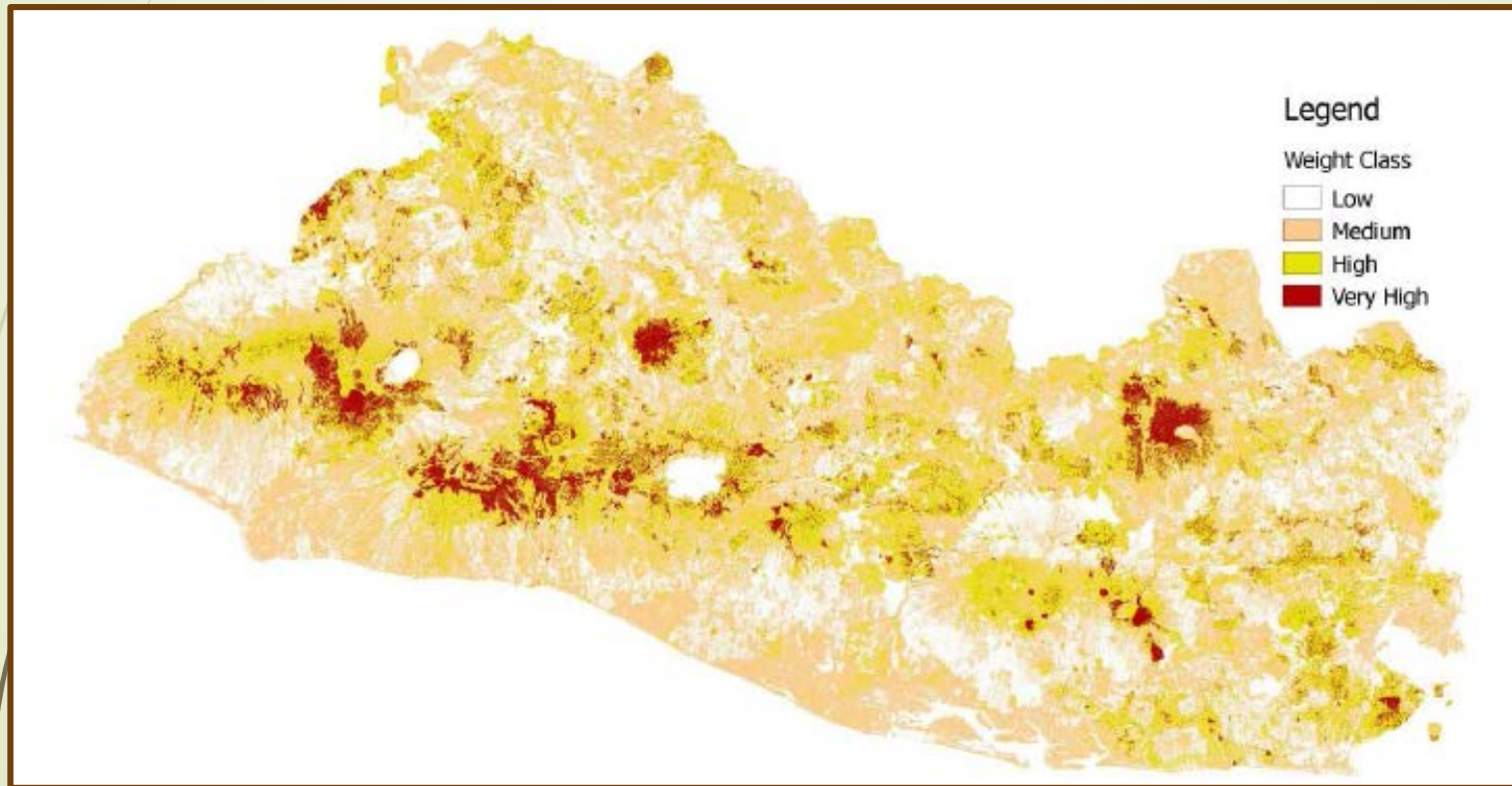
*Landslides are another natural hazard that claim thousands of lives yearly.*

*Can we leverage information from the FFG System to make informed decisions regarding potential risks for **rainfall-induced** landslides?*

*Demonstration project for landslide early warning began in 2012 with pilot project in Central America.*

# Landslide Susceptibility

*First step relates **susceptibility to landslides** to physical characteristics of land surface for historical landslide events with high resolution data. The relationship is then extended to entire country/region.*

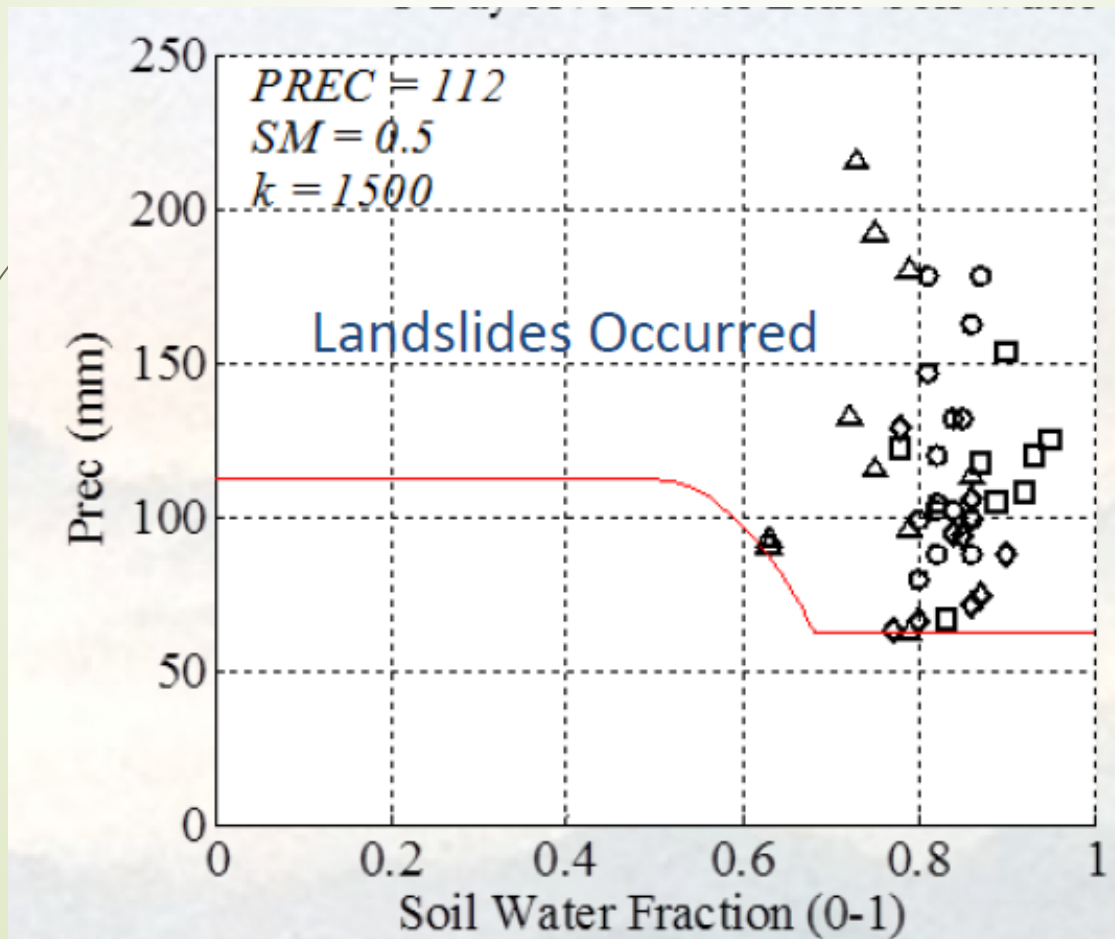


*Example Susceptibility map with 30-m resolution for country of El Salvador as part of the Central America FFG System. Susceptibility categories of low, medium, high and very high.*

*Results from El Salvador then used throughout Central America.*

# Landslide Assessment in Real-Time (1)

1) From database of historical landslide events, develop **threshold conditions of antecedent soil moisture condition and precipitation for those known events.**

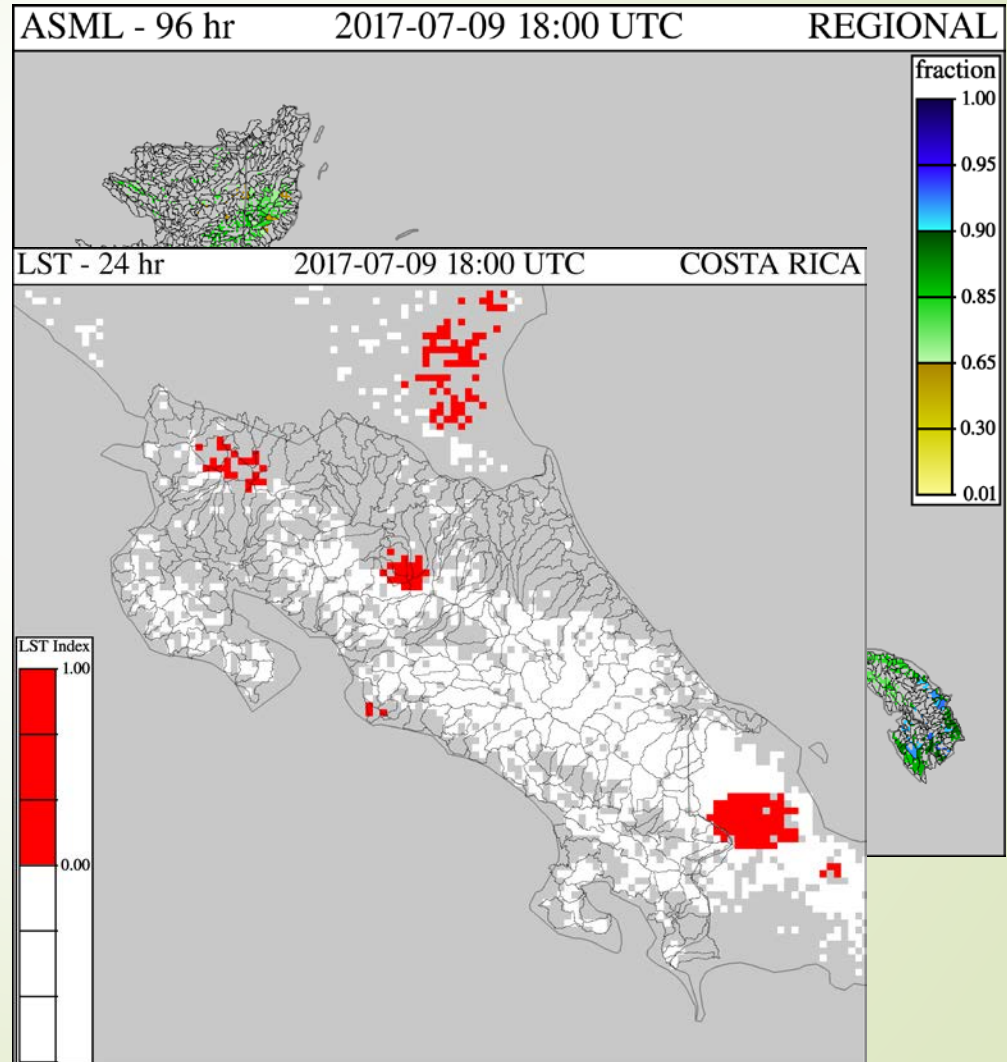




## Landslide Assessment in Real-Time (2)

**2) Use of real-time FFG system estimates of lower soil moisture and precipitation to identify at-risk watersheds.**

**3) And then the landslide susceptibility map to identify critical regions within watersheds.**



# Comments on Landslide Susceptibility & Warning

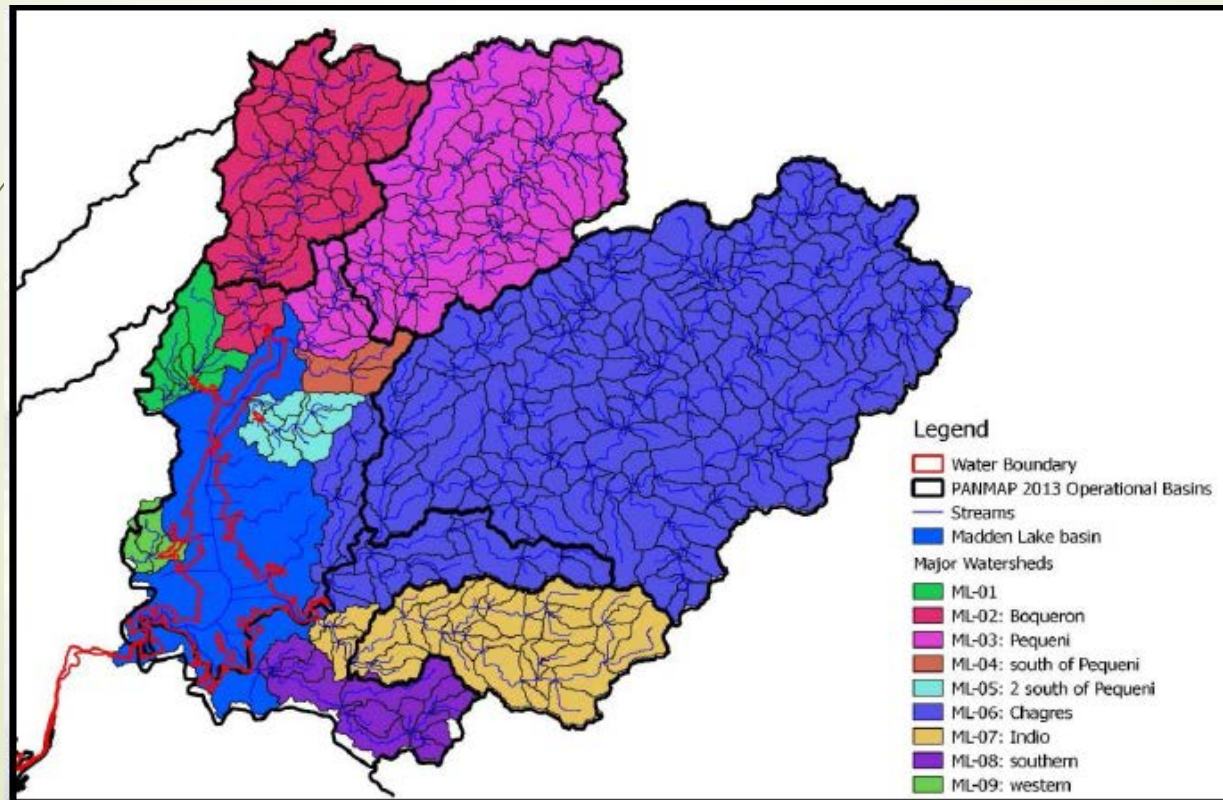
*The Central America Landslide early warning capabilities implemented within the Central America FFG System in 2016. Forecaster training also in 2016. Currently forecasters are gaining experience with products.*

*There are discussion of extending to South Asia, Southeastern Asia and Oceania, and others.*

***Historical analysis is data-intensive, requiring quality records of landslide occurrence, location and other attributes.***

# Riverine Routing and Ensemble Discharge Prediction

*Extracts sub-catchment runoff from FFG System and routes river flow through channel network at high resolution to estimate discharges. Algorithms developed to consider operation of large reservoirs (requires information on operating curves).*



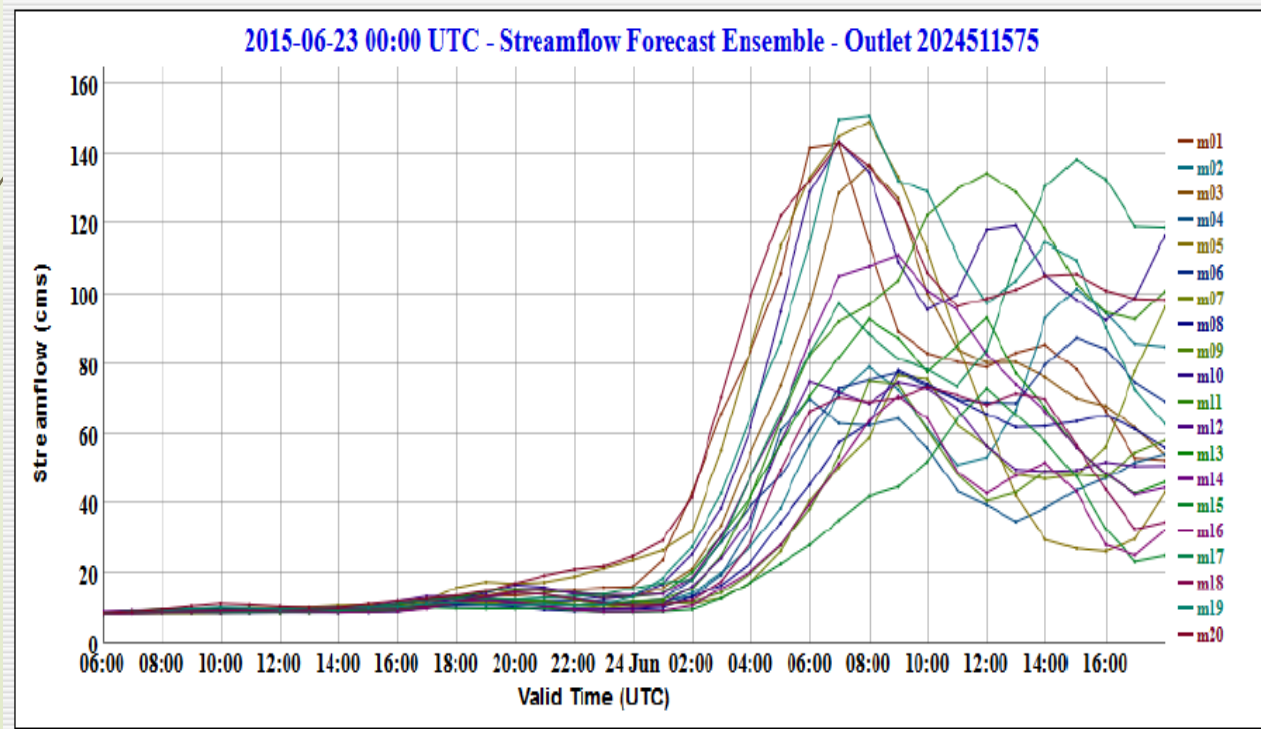
*Example of distributed flow modeling network from the Panama Canal.*

# Riverine Routing and Ensemble Discharge Prediction

*Ensemble discharge prediction if multiple NWP predictions or ensemble NWP results from single model are available.*

*Longer lead time of NWP predictions is required (> 48hours).*

*Bias adjustment on forecast precipitation will also be required.*



*Example of ensemble discharge prediction from Panama.*

# MapServer-based Forecaster Interface

## SARFFG - Southern Africa Flash Flood Guidance System

2017-07-07 22:59:53 UTC

Open Street Maps  
 SRTM 30m DEM  
 SRTM 30m DEM with Shaded Relief  
 SRTM 30m Contours  


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Zoom to Country  
South Africa

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Product Selection Table  
 Basin:  MAP  ASM  FFG  
 Raster:  06HR  12HR  24HR

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Date Nav Controls  
**Product Date: 2017-05-14 22:00 UTC**

00	01	02	03	04	05
06	07	08	09	10	11
12	13	14	15	16	17
18	19	20	21	22	23

Prev Hour    Next Hour  
 Prev 6hr Interval    Next 6hr Interval  
 Prev Day    Next Day

Reset to Current  
 Sync Date Controls

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Product Selection Table  
 Basin:  FFG  PFFT  
 Raster:  06HR  12HR  24HR

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Zoom to Country  
South Africa

 Open Street Maps  
 SRTM 30m DEM  
 SRTM 30m DEM with Shaded Relief  
 SRTM 30m Contours

MAP-06hr 2017-05-14 22:00 UTC

ASM-06hr 2017-05-14 18:00 UTC

FFG-06hr 2017-05-14 18:00 UTC

PFFT-06hr 2017-05-14 18:00 UTC

Open Street Maps  
 SRTM 30m DEM  
 SRTM 30m DEM with Shaded Relief  
 SRTM 30m Contours  


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Zoom to Country  
Select Country

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Product Selection Table  
 Basin:  ASM  FFG  
 Raster:  06HR  12HR  24HR

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Date Nav Controls  
**Product Date: 2017-05-14 22:00 UTC**

00	01	02	03	04	05
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Prev Hour    Next Hour  
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Reset to Current  
 Sync Date Controls

---

Product Selection Table  
 Basin:  PFFT  FFG  
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Zoom to Country  
Select Country

 Open Street Maps  
 SRTM 30m DEM  
 SRTM 30m DEM with Shaded Relief  
 SRTM 30m Contours

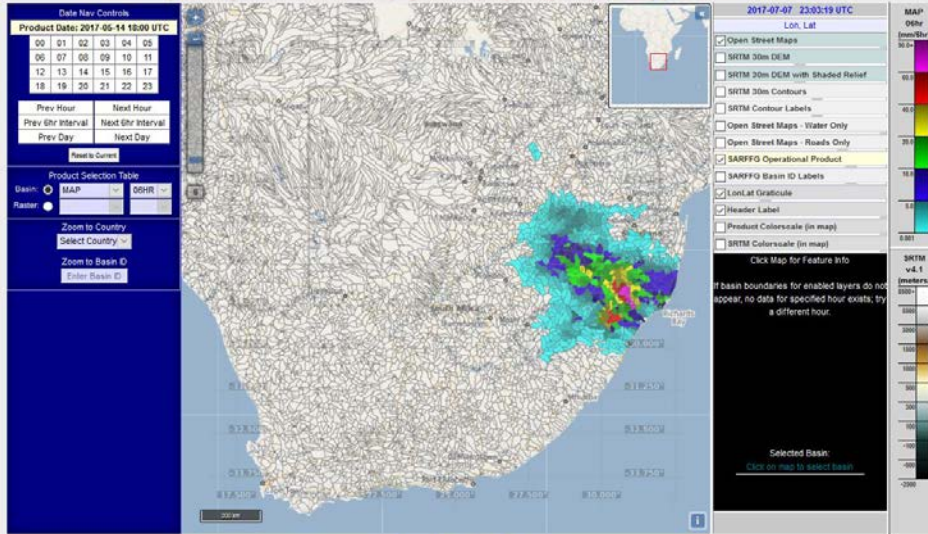
Product Viewer | Product Comparison

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# MapServer-based Forecaster Interface

## SARFFG - Southern Africa Flash Flood Guidance System

NOTE: Development in Progress - Contents and Functionality Might Break Frequently. Caching will improve loading speeds after first-time view of an area.

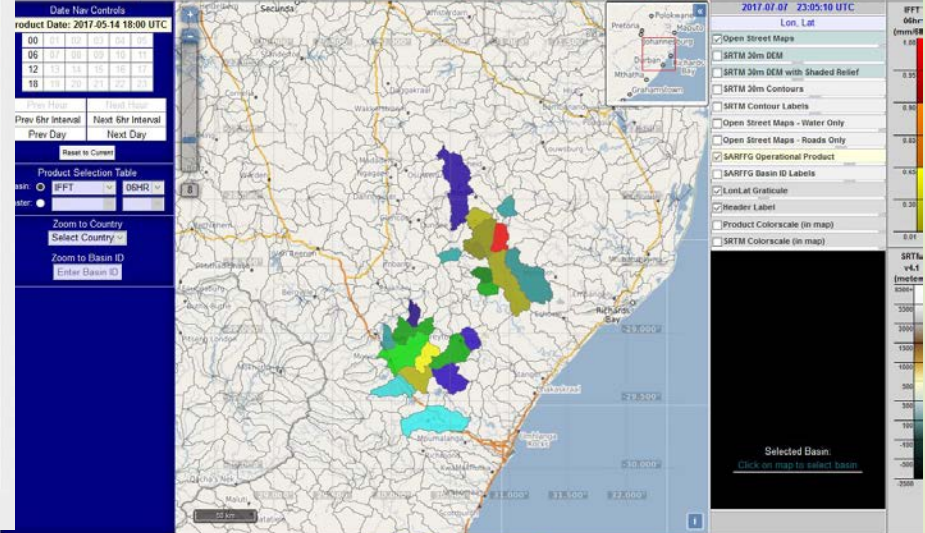


Product Viewer | Product Comparison

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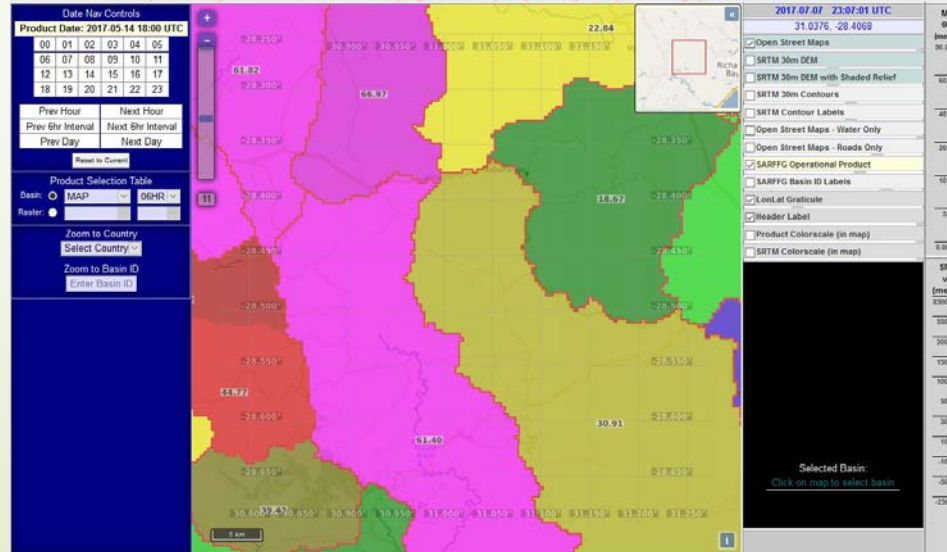
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Product Viewer | Product Comparison

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# Urban Flash Flood Warning

*Currently 50% of the worlds population lives in the urban environment. This is expected to increase to 70% by 2050.*

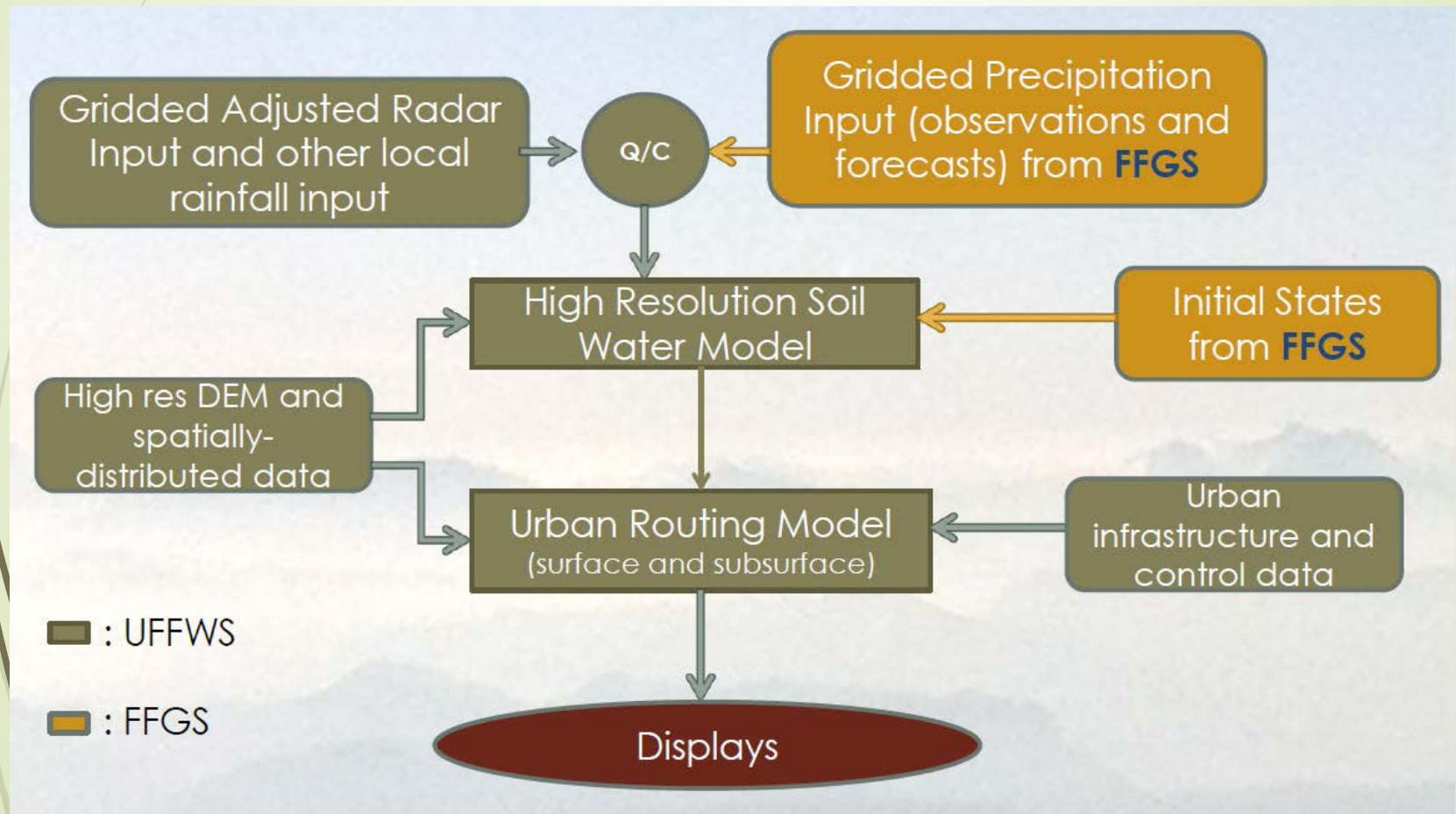
*Response to urban flash floods includes structures such as detention basins and increase storm water capacity. Warning approaches include high-instrumented catchment ALERT systems for specific area or high 2-D high resolution modeling (data intensive). Very few in developing countries.*

***Can we leverage information from the FFG System particular with respect to high resolution rainfall estimates and predictions to make informed decisions regarding potential risks for **urban flash flooding**?***

***Demonstration of capability proposed for Jakarta, Indonesia as part of the SAOFFG, as well as Istanbul, Turkey (in conjunction with BSMEFFGS).***

# Urban Flash Flood Warning

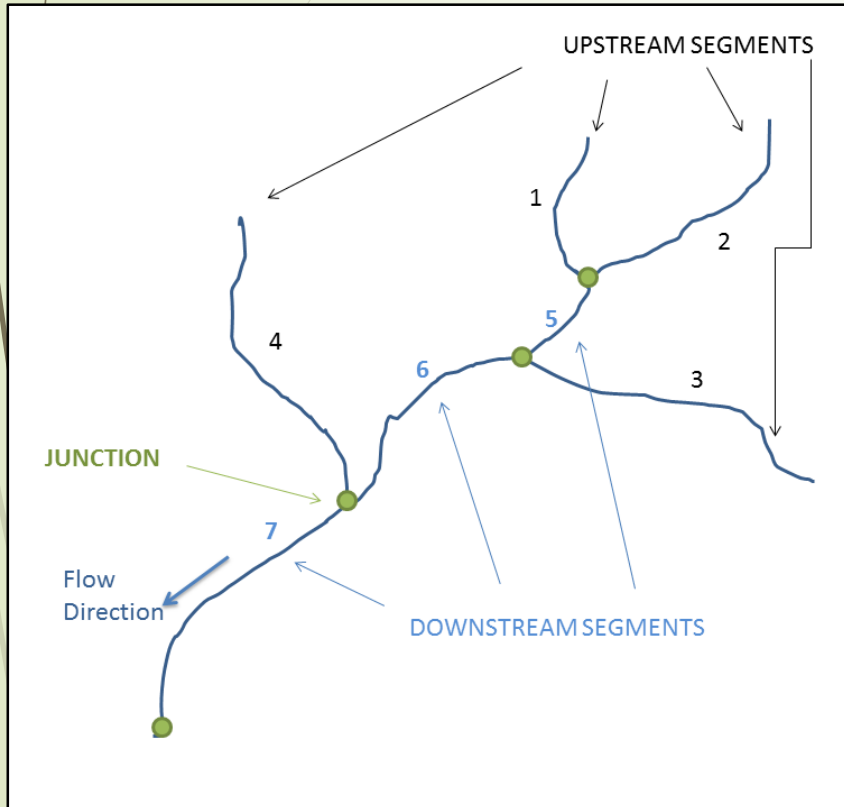
*Builds upon data available from FFGS (precipitation, model conditions) and includes high resolution modeling in urban area to include both surface and subsurface flow routing.*





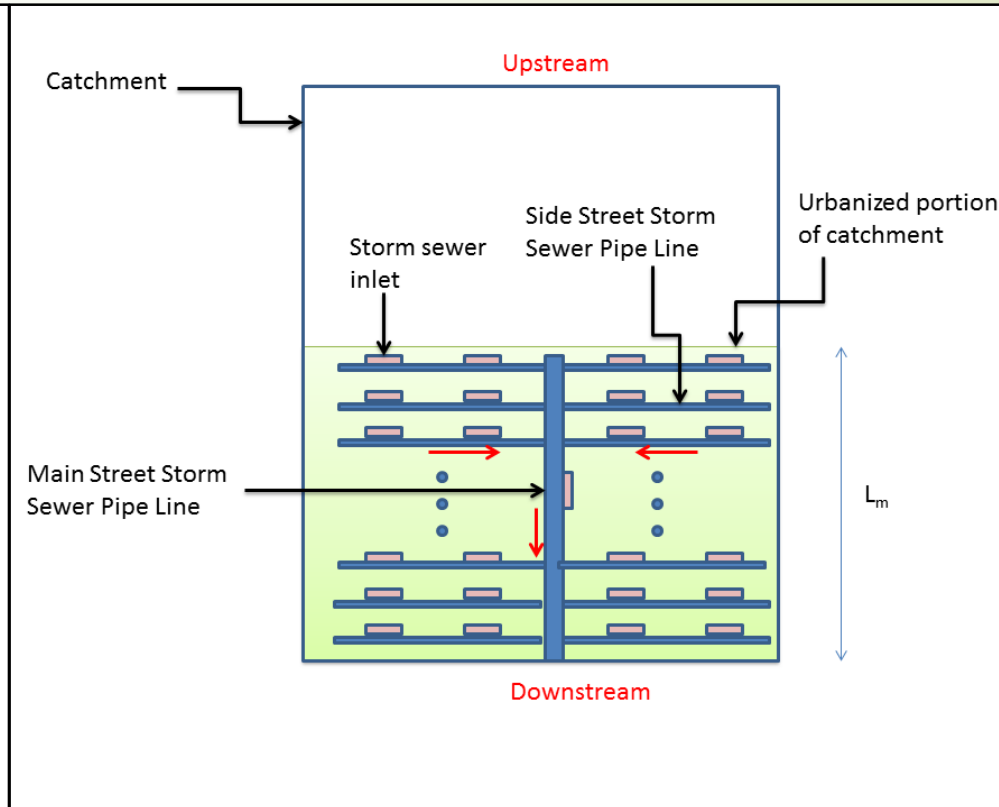
# Basic Elements of Urban Flash Flood Warning

## Natural or modified surface drainage



Requires information on stream or canal network, capacity, and control structures.

## Sub-surface drainage



Requires information on storm sewer network, including number of inlets, inlet capacity, storm sewer capacity, and control.

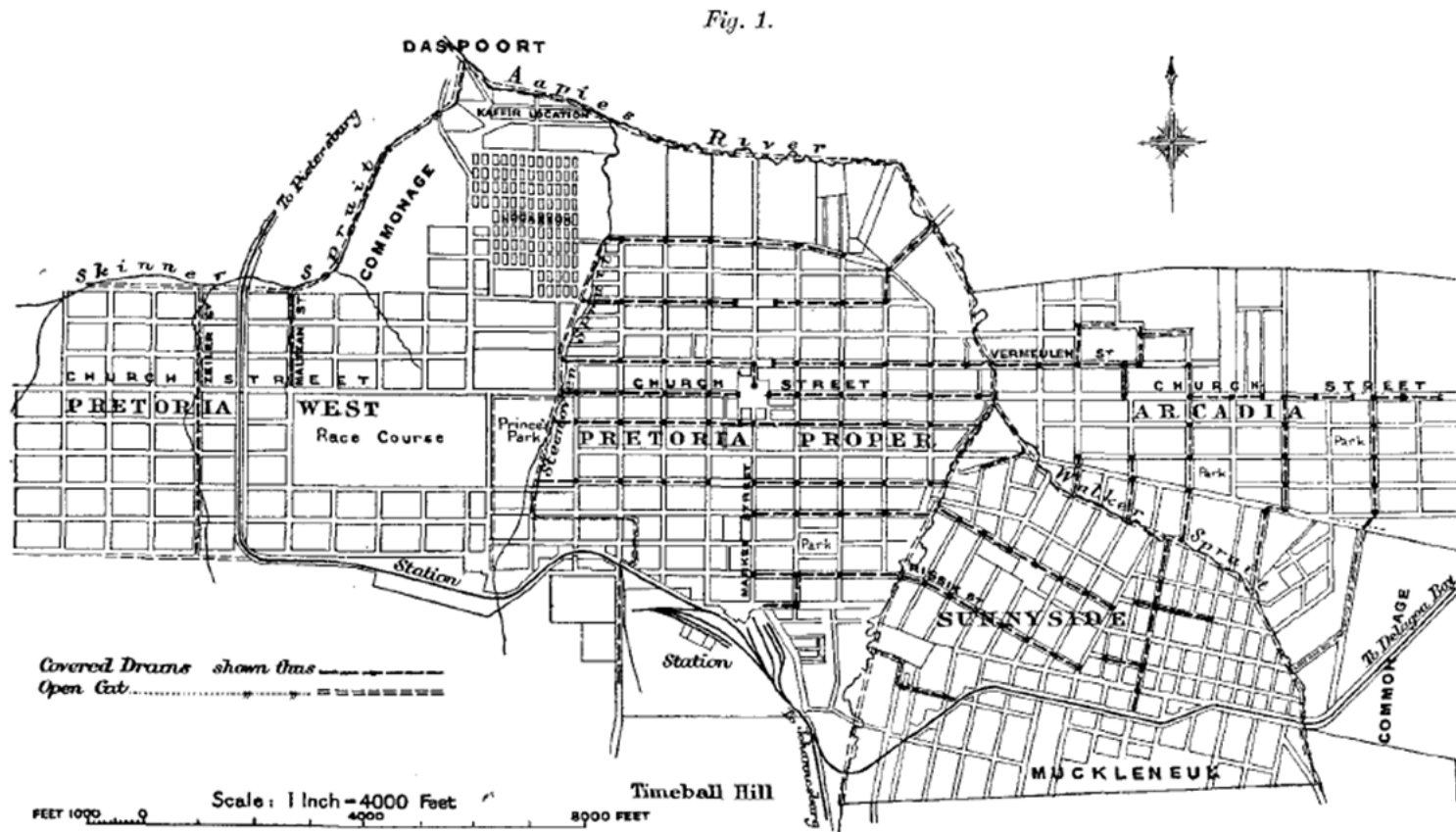
# Urban Flash Flood Warning Demonstration for Pretoria

*Demonstration for the municipality of Pretoria, Rep. of South Africa.*



# Urban Flash Flood Warning Demonstration for Pretoria

*Illustration of storm sewer network as originally designed from City of Pretoria Engineers Office.*



278 BADDOCK ON STORM-WATER DRAINAGE OF PRETORIA. [Selected

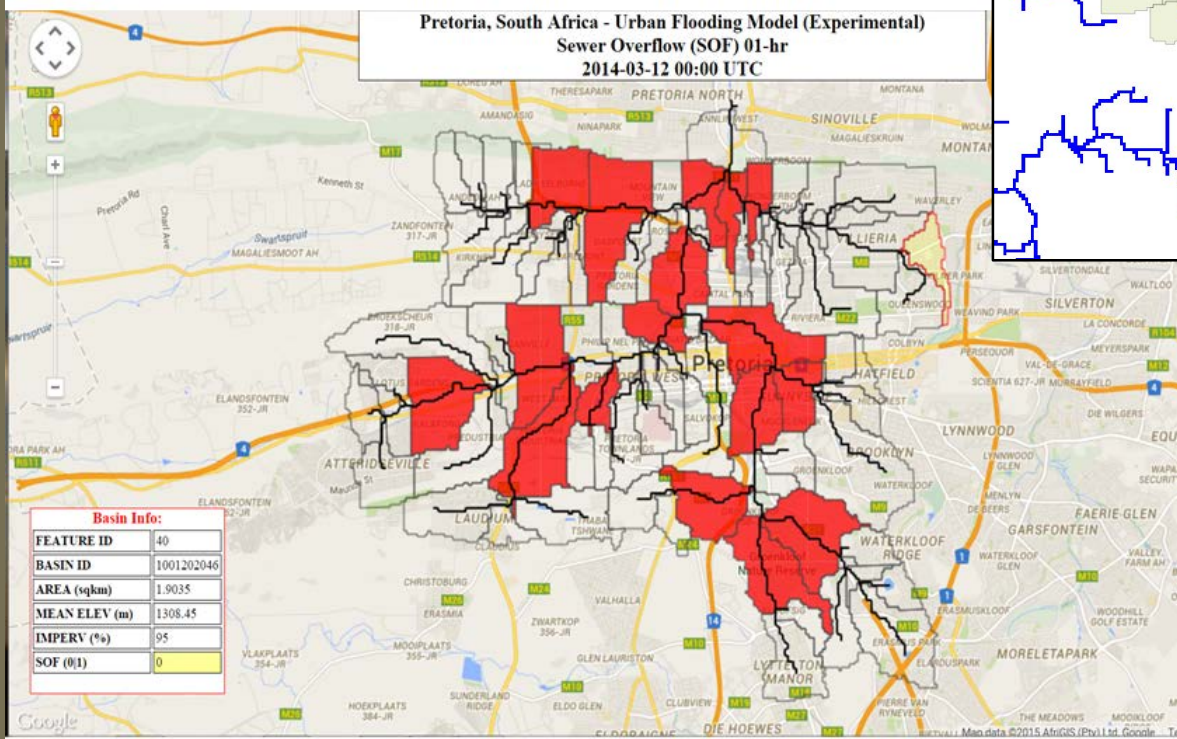
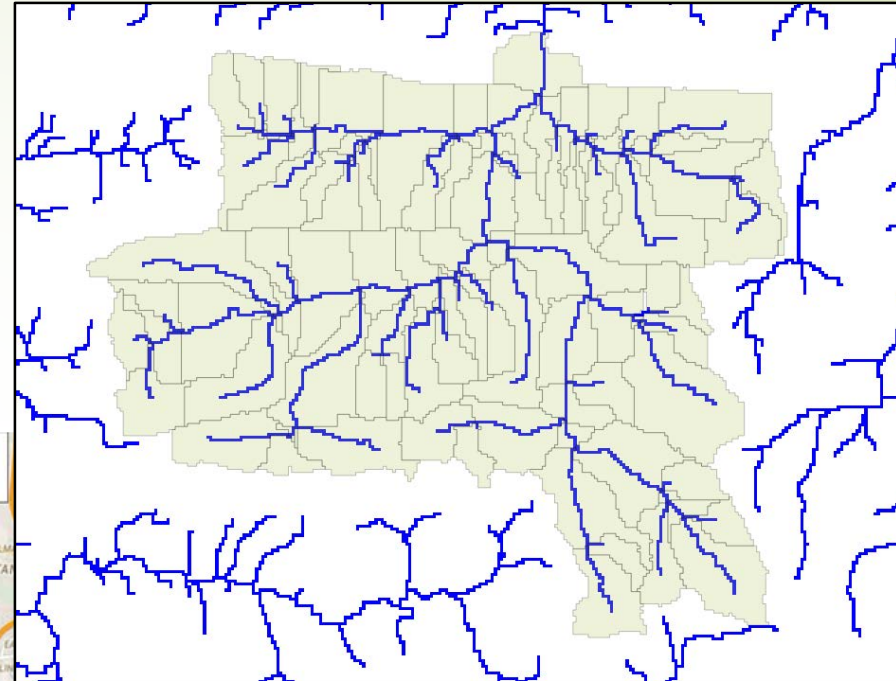
# Urban Flash Flood Warning

*Urban watersheds define at a resolution of 2 km<sup>2</sup>. This is surface network.*

*Used storm sewer network diagram to define sub-surface network.*

*Surface and subsurface flow modeled.*

*Red watersheds below indicate where system indicates storm sewer overflow.*



# Needs for Jakarta Urban Flash Flood Warning

*Establishment of a multi-agency consortium to support the development and sustainability of the urban flash flood warning system and for effective urban flash flood warning and response.*

- *National Meteorological and Hydrological Services*
- *Municipality Planning and Management Offices*
- *City or Municipality Engineers Office*
- *Disaster Management and Response Agencies*
- *Other involved agencies*

*Training of operational forecasters on urban flash flood issues as well as cross-training with engineering and response agencies on capabilities and needs. Development of response protocols.*

# Data Needs for Jakarta Urban Flash Flood Warning

## ❖ **Infrastructure Information**

- *Surface channel network (GIS/CAD format)*
- *Surface channel / canal flow capacity (cross-sections)*
- *Sub-surface drainage network*
- *Storm sewer inlet characteristics (number, location, capacity)*
- *Storm sewer characteristics (size/capacity)*
- *Detention basin locations and control characteristics*
- *Upstream reservoirs locations and control characteristics*

## ❖ **Real-Time and Historical Data**

- *Radar estimates of precipitation*
- *Rain gauge data*
- *NWP precipitation estimates*

## ❖ **Historical Data**

- *Streamflow or water level (for calibration)*
- *Tide information*

# On-going Enhancements to FFG Systems

