INTRODUCTION TO THE FLASH FLOOD GUIDANCE (FFG) SYSTEM FOR SOUTHEAST ASIA

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http://www.hrcwater.org

Flash Flood Guidance System for Southeast Asia

- Program is in coordination with the World Meteorological Organization and the Climate Risk Early Warning Systems initiative (CREWS)

- Hydrologic Research Center (HRC) is the technical implementer of the program

Overview

1. Floods and flash floods in perspective
2. Impacts of Flooding
3. Basic Meteorology of rainfall systems causing flash floods
4. Basic river Hydrology from a flash flooding perspective
5. Forecasting Flash Floods
6. Conclusions

1. Floods and flash floods in perspective

Distributed Hydrologic Model

- *Tool for short and long term forecasting of floods*
- *Produces entire hydrographs (w/ high uncertainty on small scales)*
- *Difficult to ingest local precipitation information after model cycle*
- *Awkward for local forecasters to make adjustments, needed for reliable flash flood warning*

Flash Flood Guidance

- *Diagnostic tool useful for quick flash flood occurrence diagnosis and short term prediction*
- *Concerns bankfull flows*
- *Readily ingests local precipitation information*
- *Local forecaster adjustments easy*
- *Promotes Close Collaboration of Hydrologists with Meteorologists*

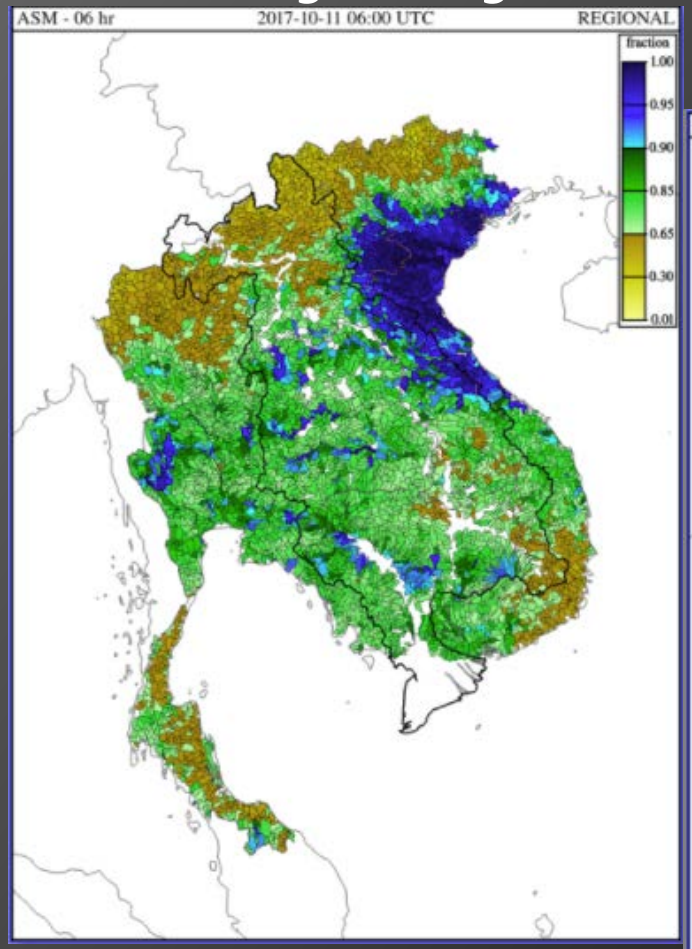
Definitions of Flash Floods

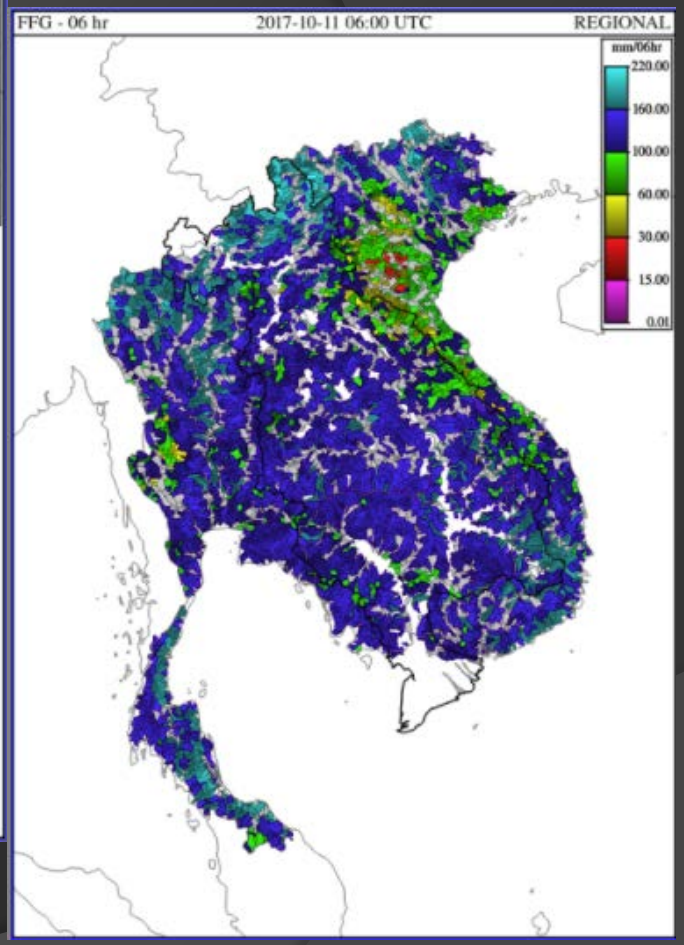
- World Meteorological Organization - A flood of short duration with a relatively high peak discharge
- American Meteorological Society – A flood that rises and falls quite rapidly with little or no advance warning, usually as the result of intense rainfall over a relatively small area
- Response time is 6 hours or less
- A local hydrometeorological phenomenon that requires:
  - BOTH Hydrological and Meteorological expertise for real time forecasting/warning
  - Knowledge of local up to the hour information for effective warning (24 - 7 operation)

The Need

- Large-river flood-warning strategies ineffective for flash floods

- Response time in the range of 1-6 hours.
- As opposed to river floods, flash floods have a quick response to rainfall input.
- Upland basins are most likely killers.





Flash Floods in Perspective

Where as river flood forecasting is generally a *Hydrological* problem, flash flood forecasting is a ***Hydro-meteorological*** problem.

2. Impacts of Flooding

Economic Impacts of Flooding

- Revenue Loss
- Impacts Tourism
- Loss of investment
- Impacts to infrastructure and property
- Loss of jobs

Social Impacts of Flooding

- Water supply disruptions
- Drinking water quality problems
- Drownings and displaced people
- House and dwelling destruction
- Damages to roads leading to communities cut off from aid
- Crop losses
- Epidemics – cholera, diarrhea, malaria outbreaks

3. Basic Meteorology of rainfall systems causing flash floods

Some Prominent Weather Patterns Causing Weather Related Disasters

Some of the Southeast Asia Region rainfall is caused by the following triggering mechanisms….

- ITCZ
- Tropical Depression
- Low pressure systems
- Tropical Storms
- Typhoons
- … too name a few ……

Factors that suggest a rainfall event may lead to a flash flood include. 1) slow movement of a system,

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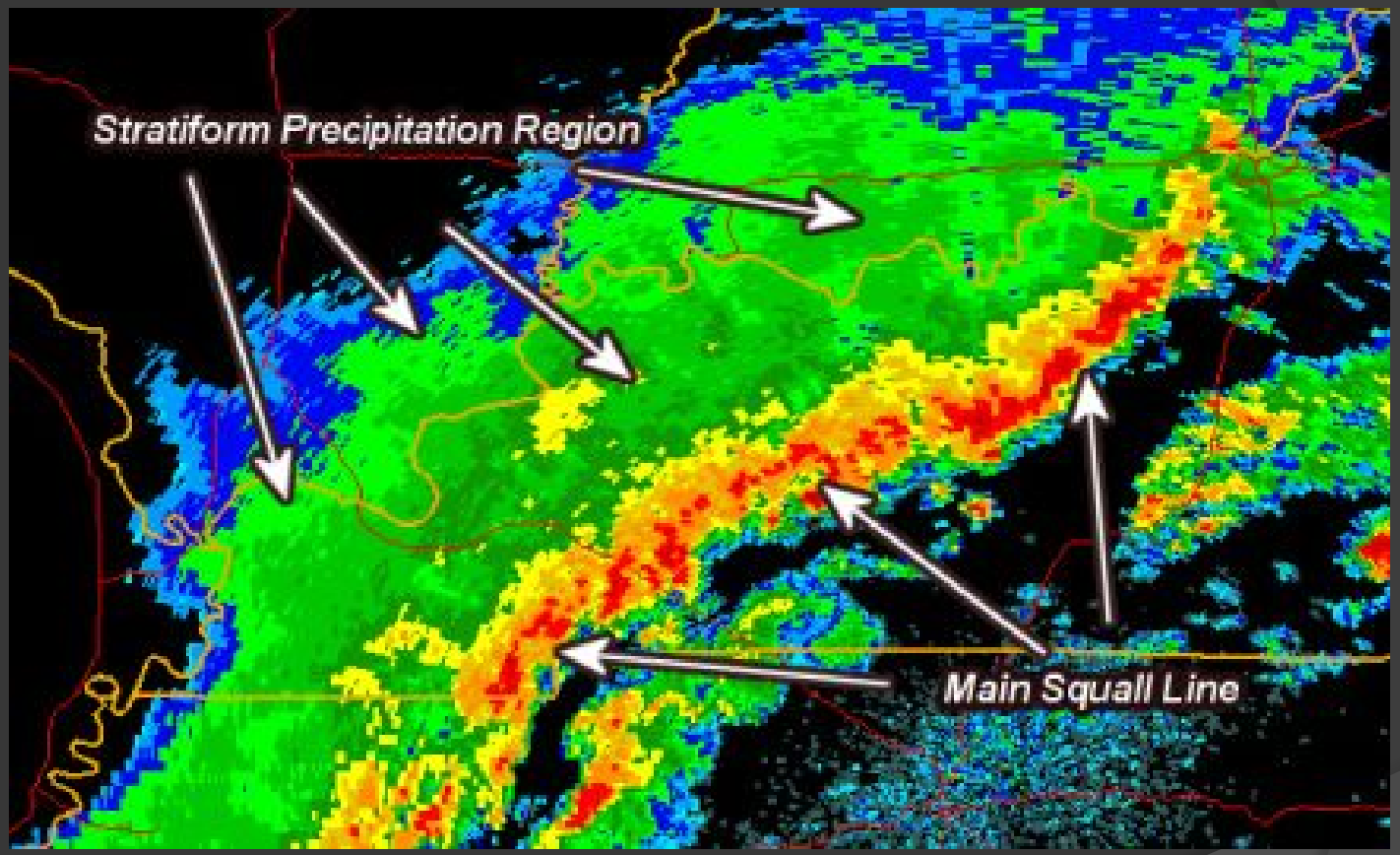


2) prolonged heavy-to-intense rainfall rates,

Factors that suggest a rainfall event may lead to a flash flood include. 1) slow movement of a system, 2) prolonged heavy-to-intense rainfall rates,

3) areal coverage of intense rainfall rates.

So in summary ……

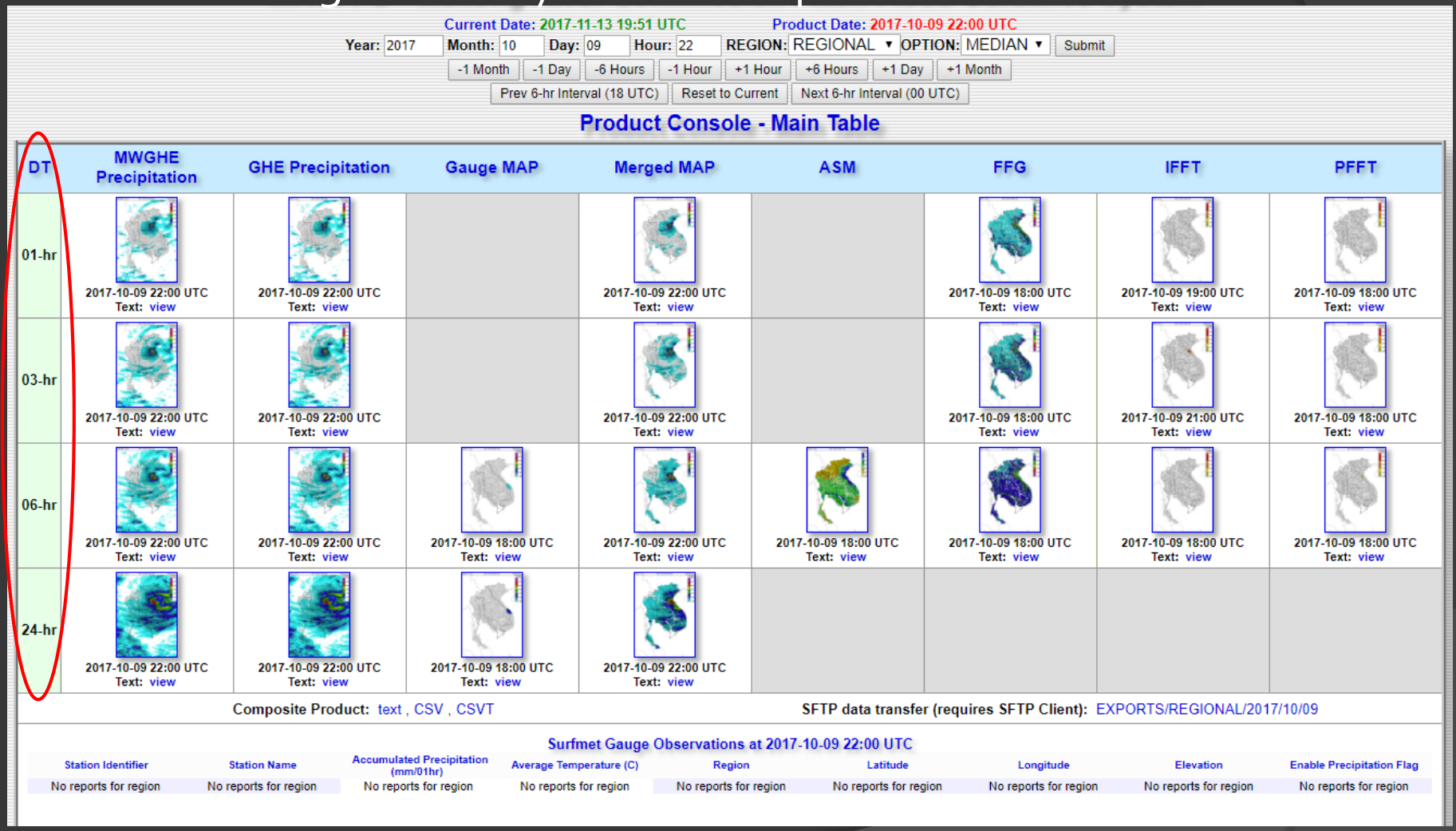
In order for a flash flood to occur, heavy precipitation must fall in a region that has appropriate hydrological ingredients in place.

For heavy precipitation to occur, high rainfall rates must be sustained.

Long duration of high rainfall rates results from slow movement of the rainfall-producing system.

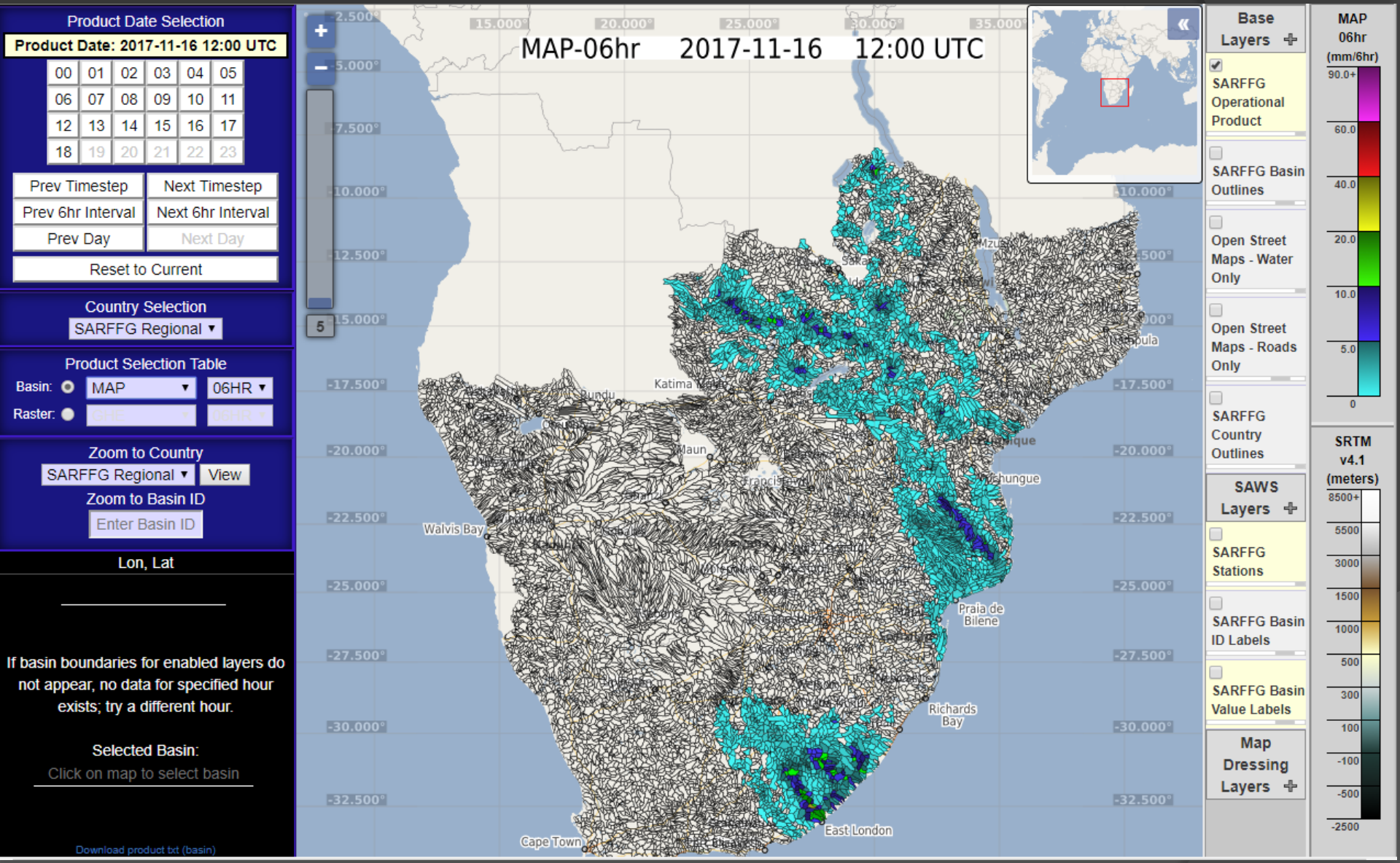
Standardized FFG System Forecaster User Interface

The flash flood guidance system offers products to assist forecasters



Thumbnails to access a Map Server Interface

Mapserver Interface Prototype



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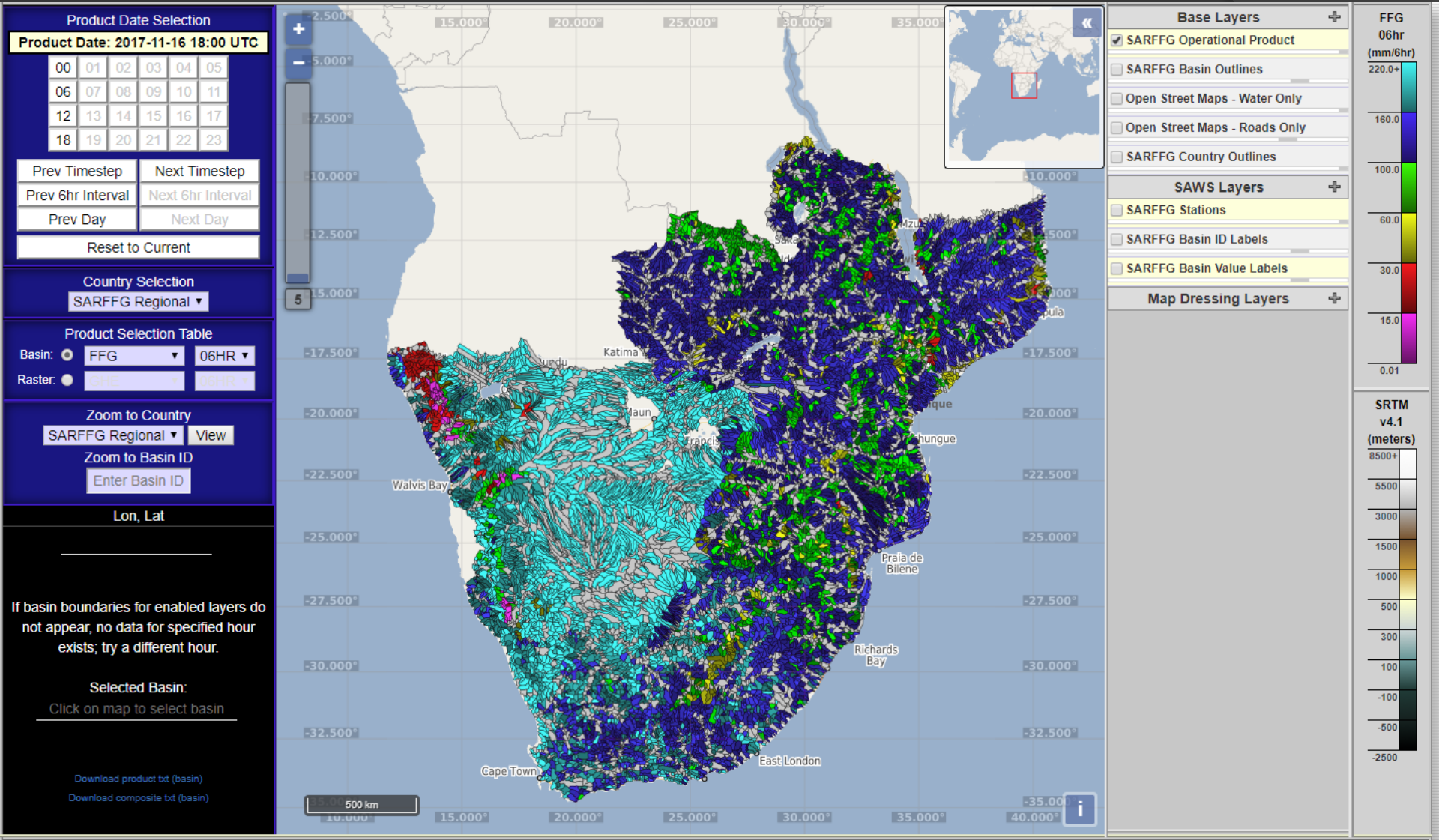

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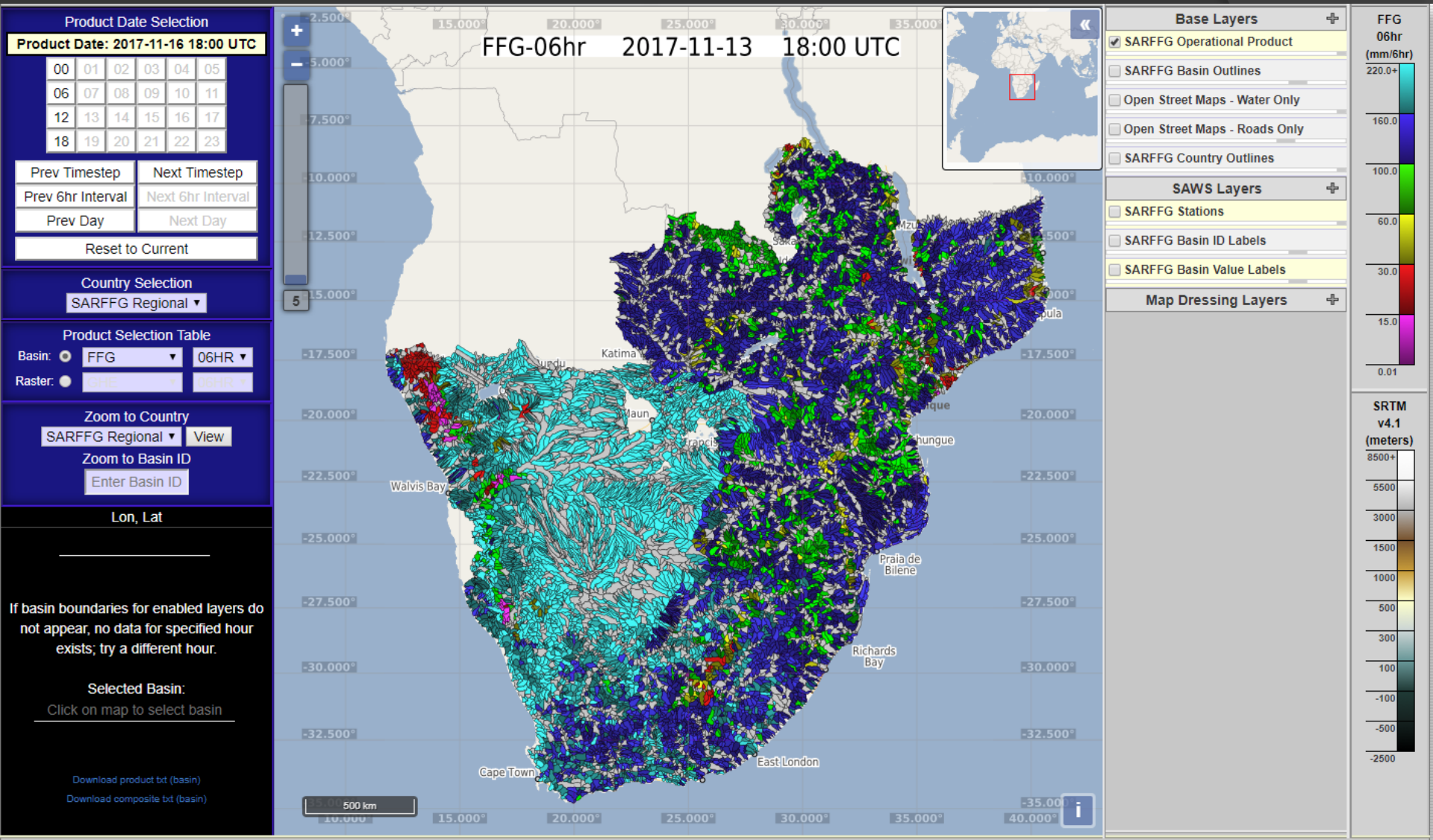

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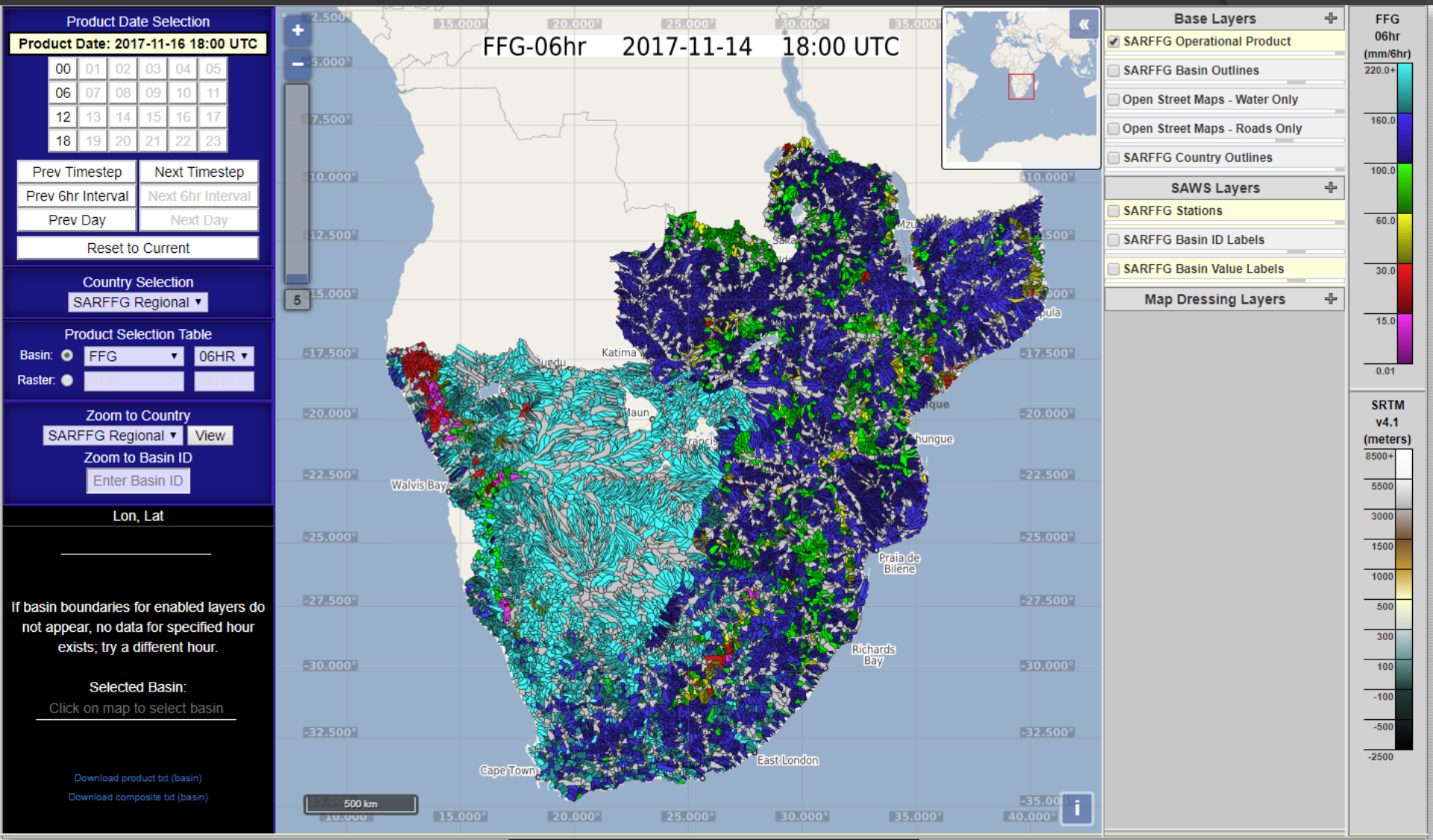
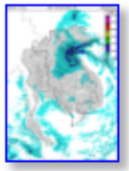
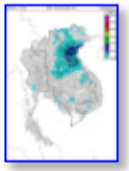
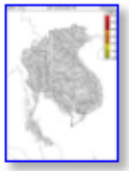
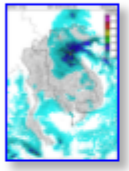
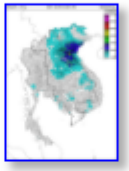
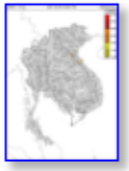
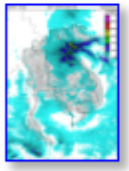
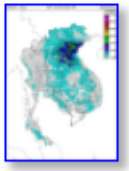
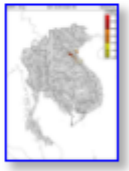
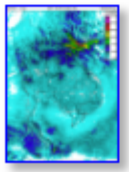
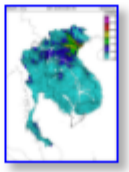


Standardized FFG System Forecaster User Interface

Product Console - Model Forecast Products

DT	WRF Forecast	FMAP	FFFT
01-hr	 2017-10-09 22:00 UTC Text: view	 2017-10-09 22:00 UTC Text: view	 2017-10-09 18:00 UTC Text: view
03-hr	 2017-10-09 22:00 UTC Text: view	 2017-10-09 22:00 UTC Text: view	 2017-10-09 18:00 UTC Text: view
06-hr	 2017-10-09 22:00 UTC Text: view	 2017-10-09 22:00 UTC Text: view	 2017-10-09 18:00 UTC Text: view
24-hr	 2017-10-09 22:00 UTC Text: view	 2017-10-09 22:00 UTC Text: view	

Product Console Baseline Threat Products

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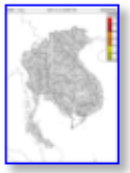
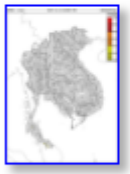
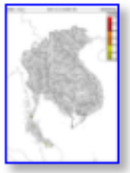
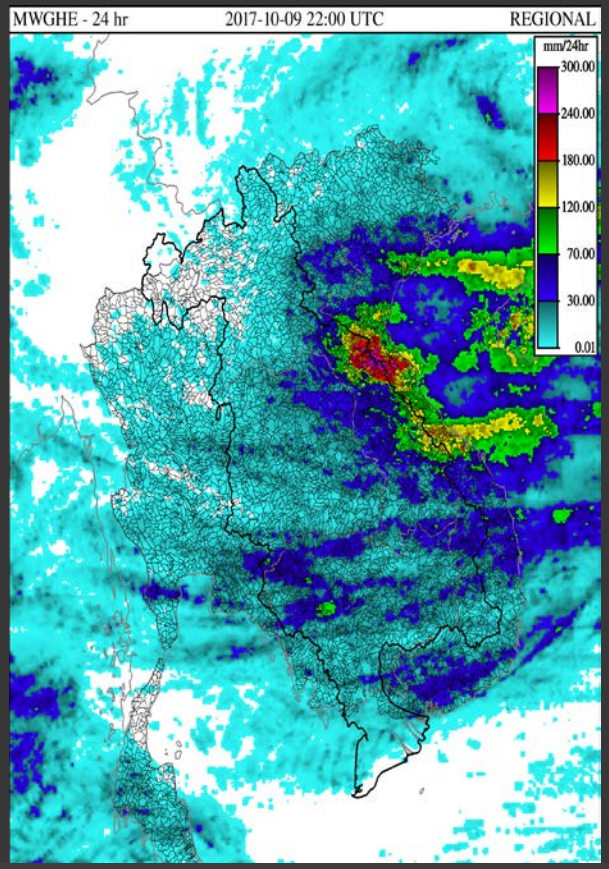
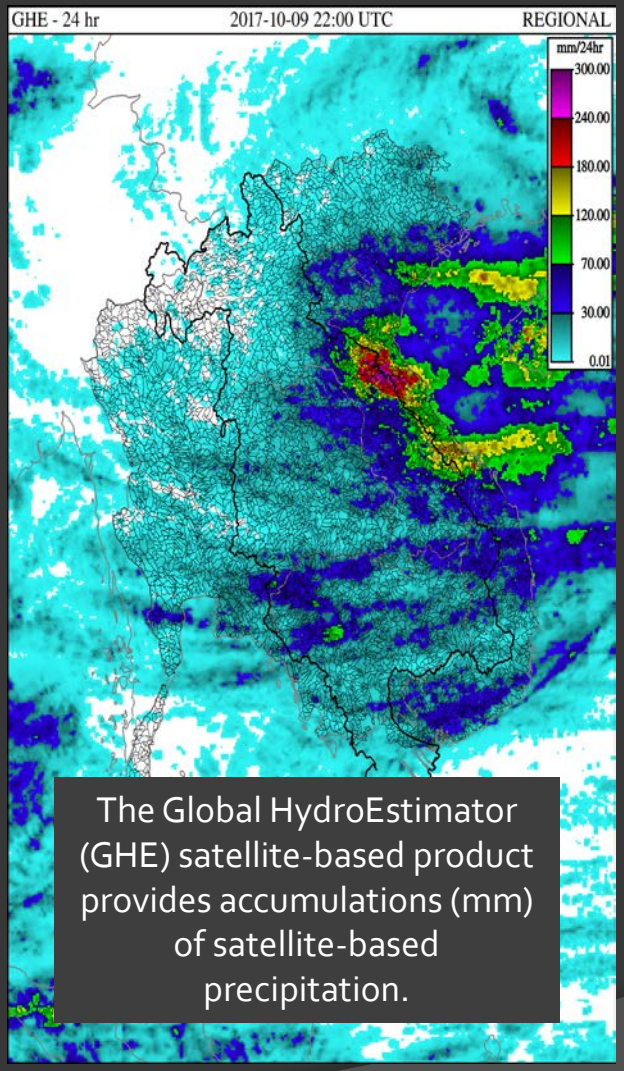
12-hr	 2017-11-13 18:00 UTC Text: view
24-hr	 2017-11-13 18:00 UTC Text: view
36-hr	 2017-11-13 18:00 UTC Text: view

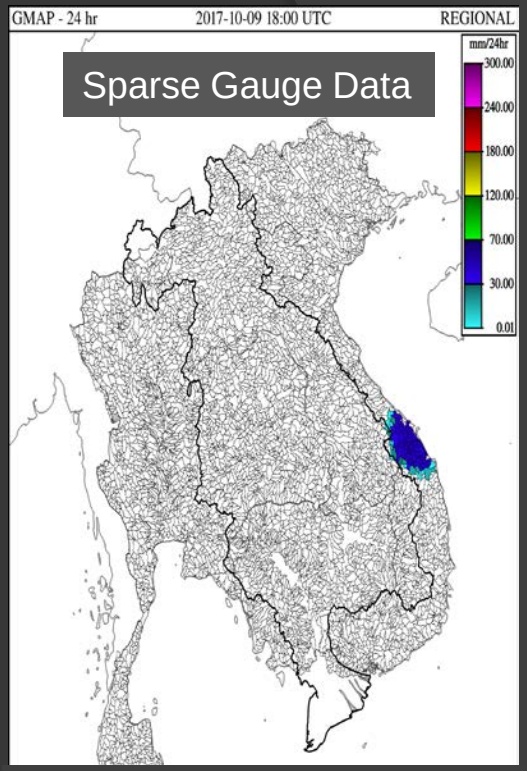
The flash flood guidance system offers products to assist forecasters



The Microwave-adjusted Global HydroEstimator satellite-based product provides accumulations of infrared-based precipitation (mm).

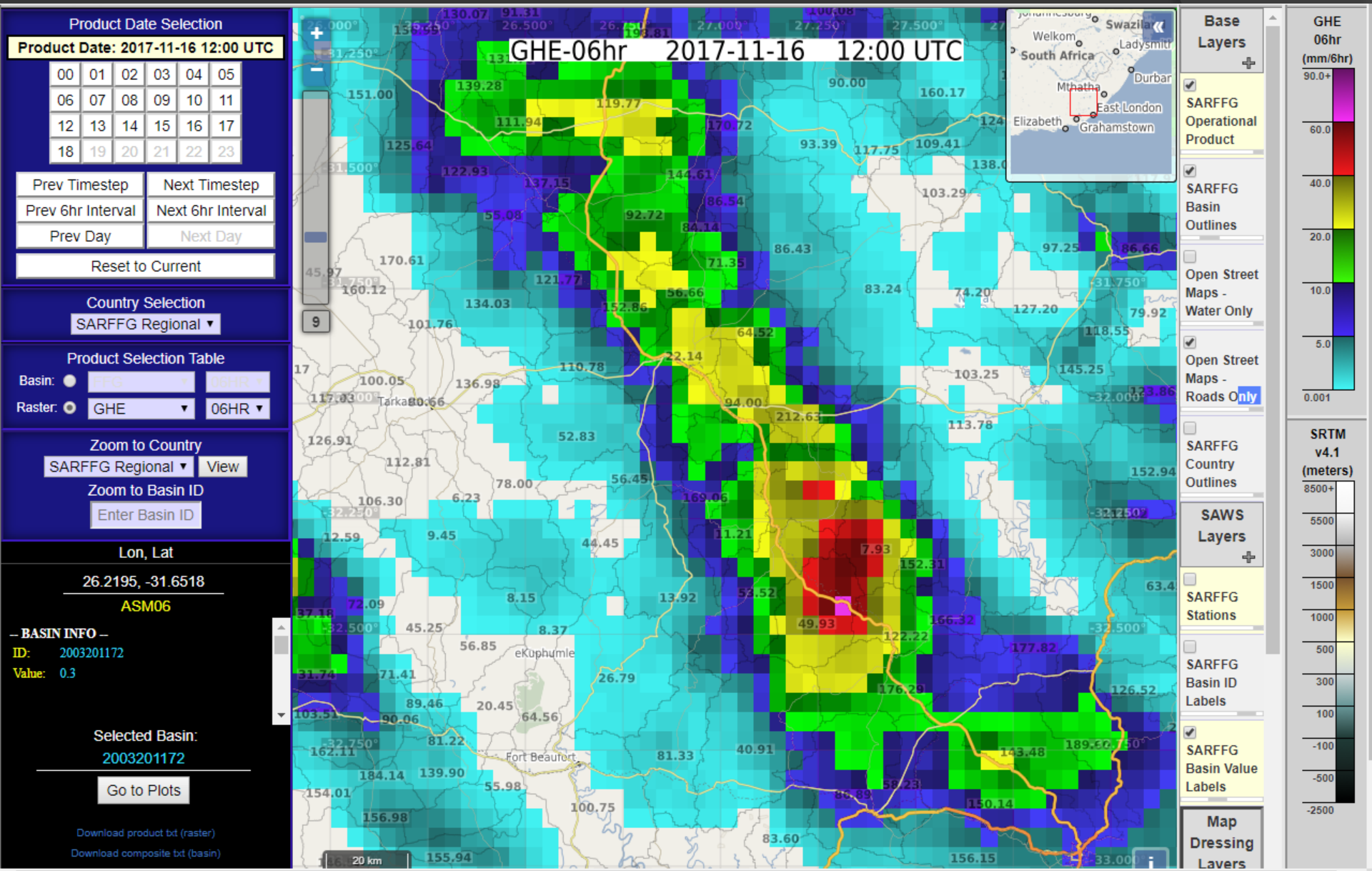


The Global HydroEstimator (GHE) satellite-based product provides accumulations (mm) of satellite-based precipitation.



Mean areal precipitation for each flash flood basin based on gauges

Mapserver Interface Prototype



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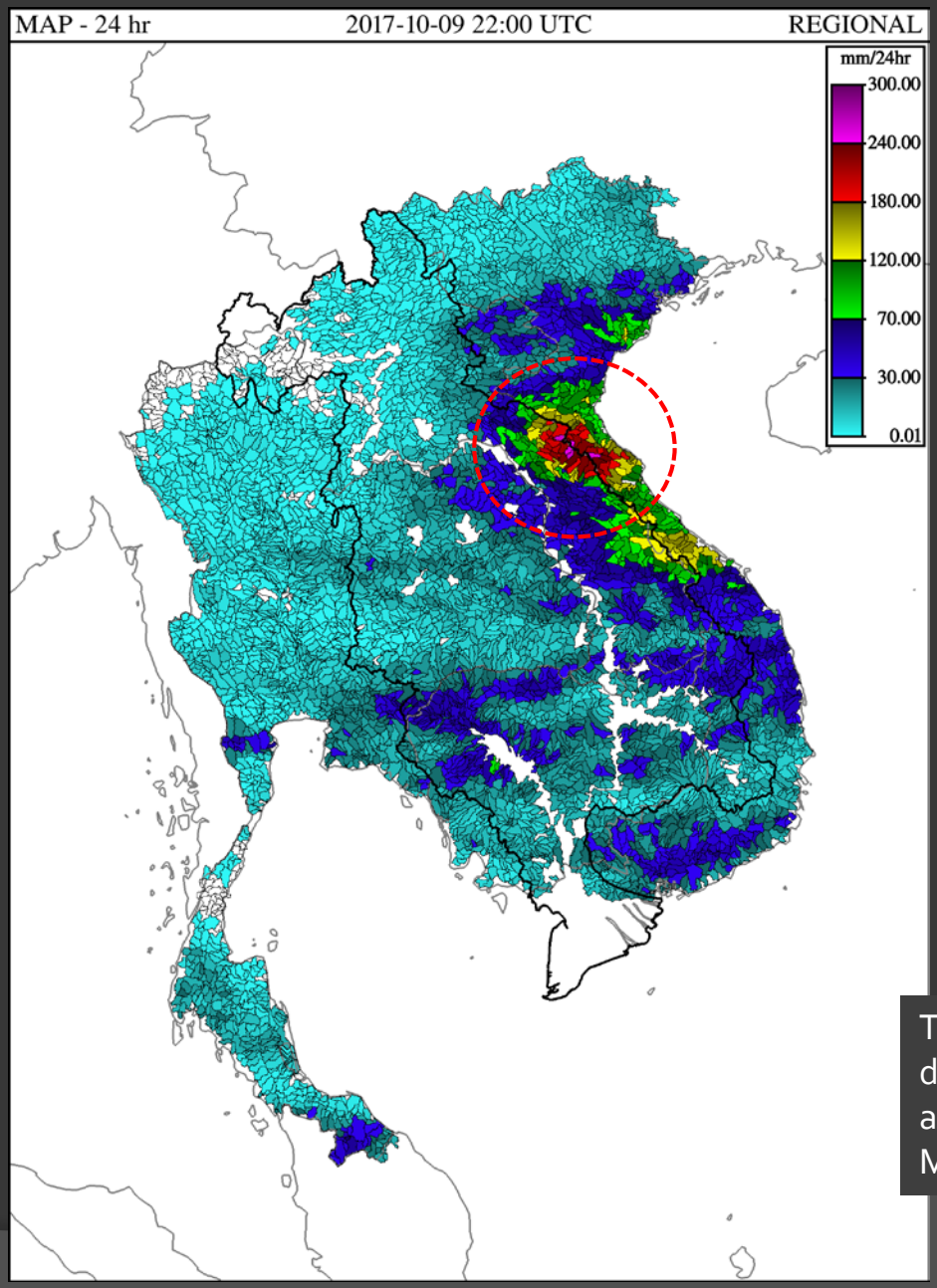
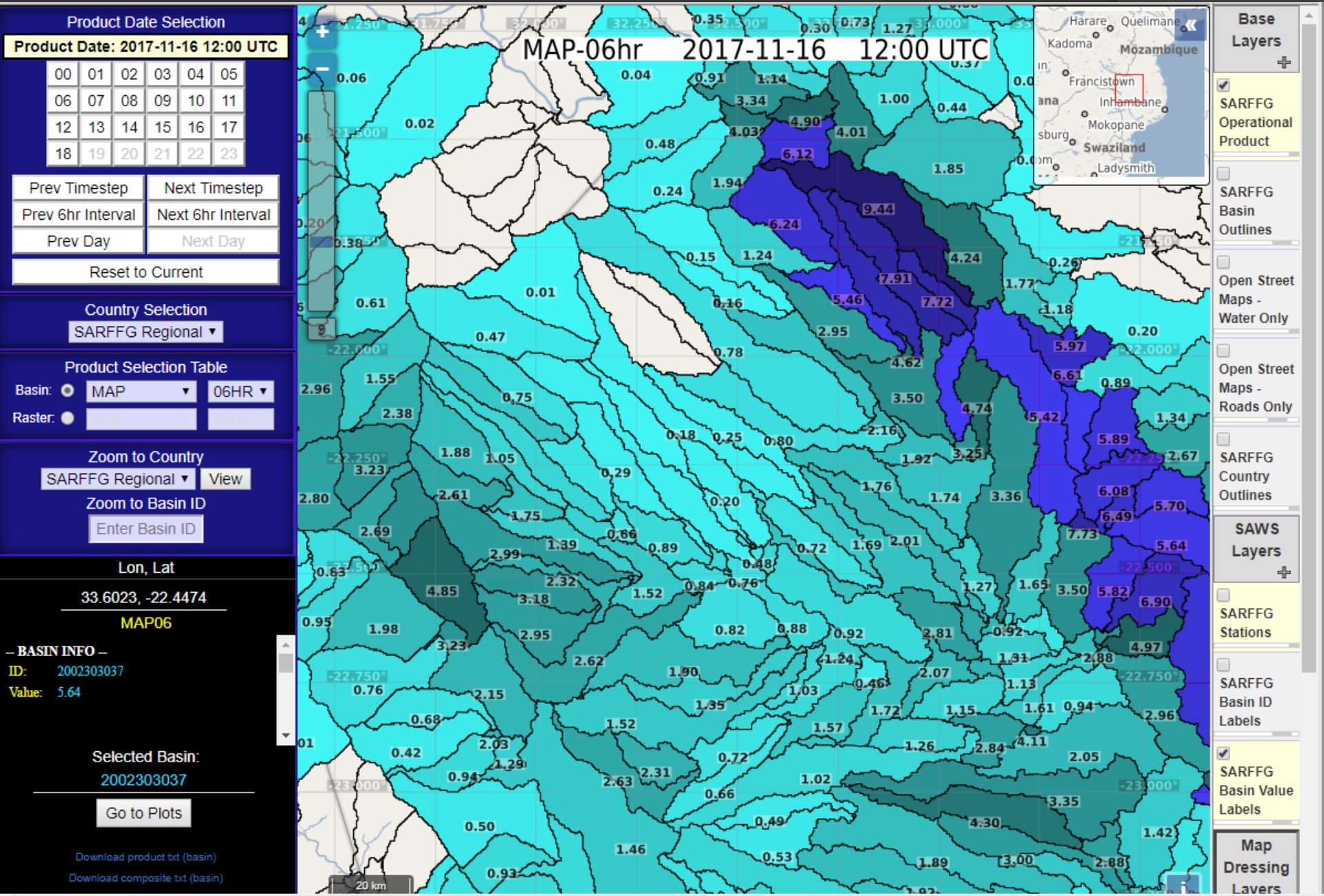


The Merged Mean Areal Precipitation (MAP) product is derived for each basin and is based on the best available mean areal precipitation estimates from the MWGHE, GHE and gauges.

Mapserver Interface Prototype



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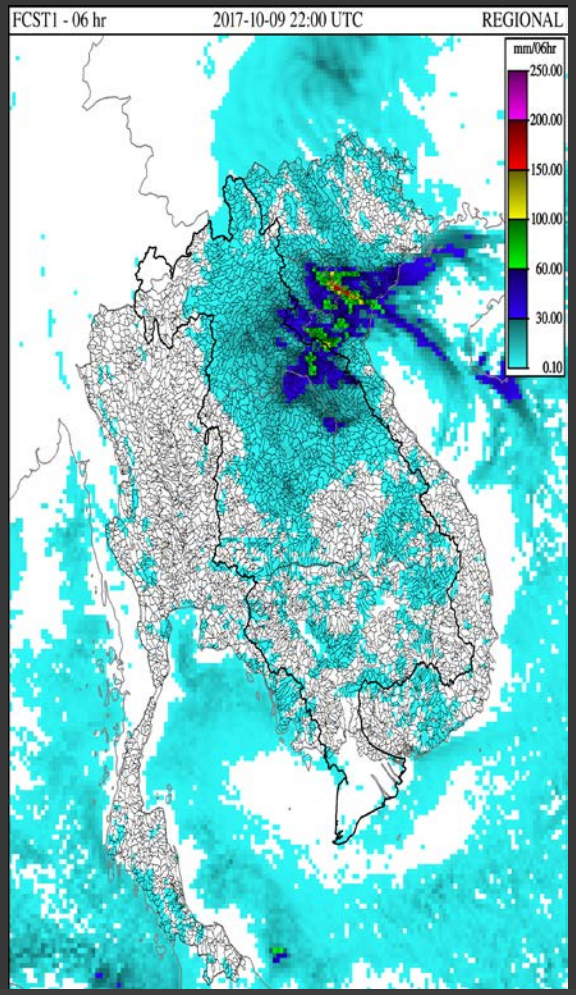
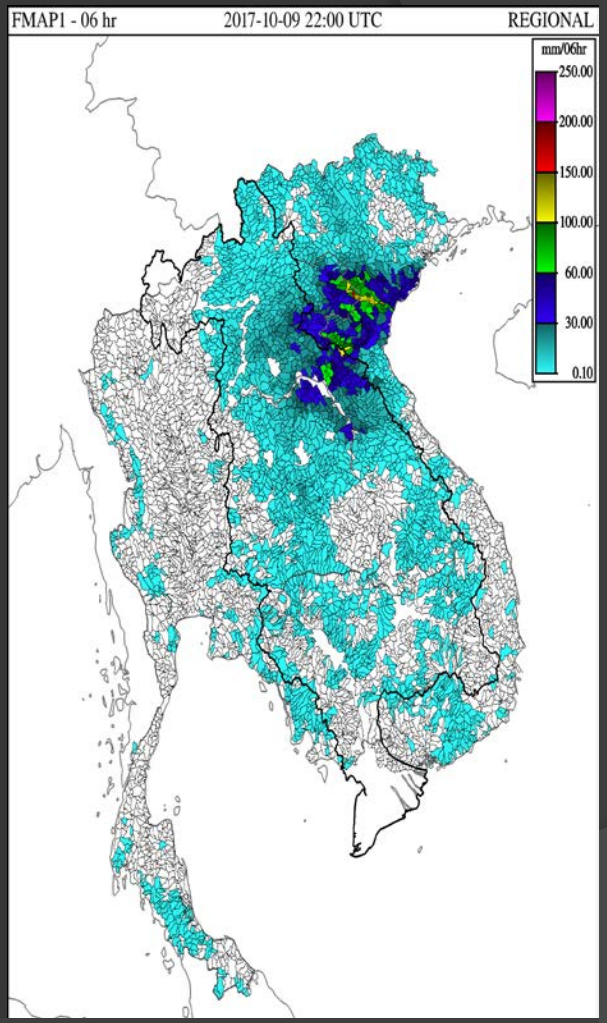


Quantitative precipitation forecast (QPF) – WRF Mesoscale Model



The Forecast Mean Areal Precipitation (FMAP) product reflects rainfall accumulations produced using numerical forecasts of basin-average precipitation.

4. Basic river hydrology from flooding perspective

Flash floods are not generated purely by intense rainfall but also by the hydrologic processes of the land surface on which the rainfall occurs.

It is the interaction between meteorology and hydrology of a location - where the complex interrelationships between:

- atmospheric moisture,
- the terrain,
- soil moisture content,
- and geomorphology

can result in the enhancement of the runoff potential of a given rainfall event, increasing the likelihood of a flash flood event.

Dependent on two factors:

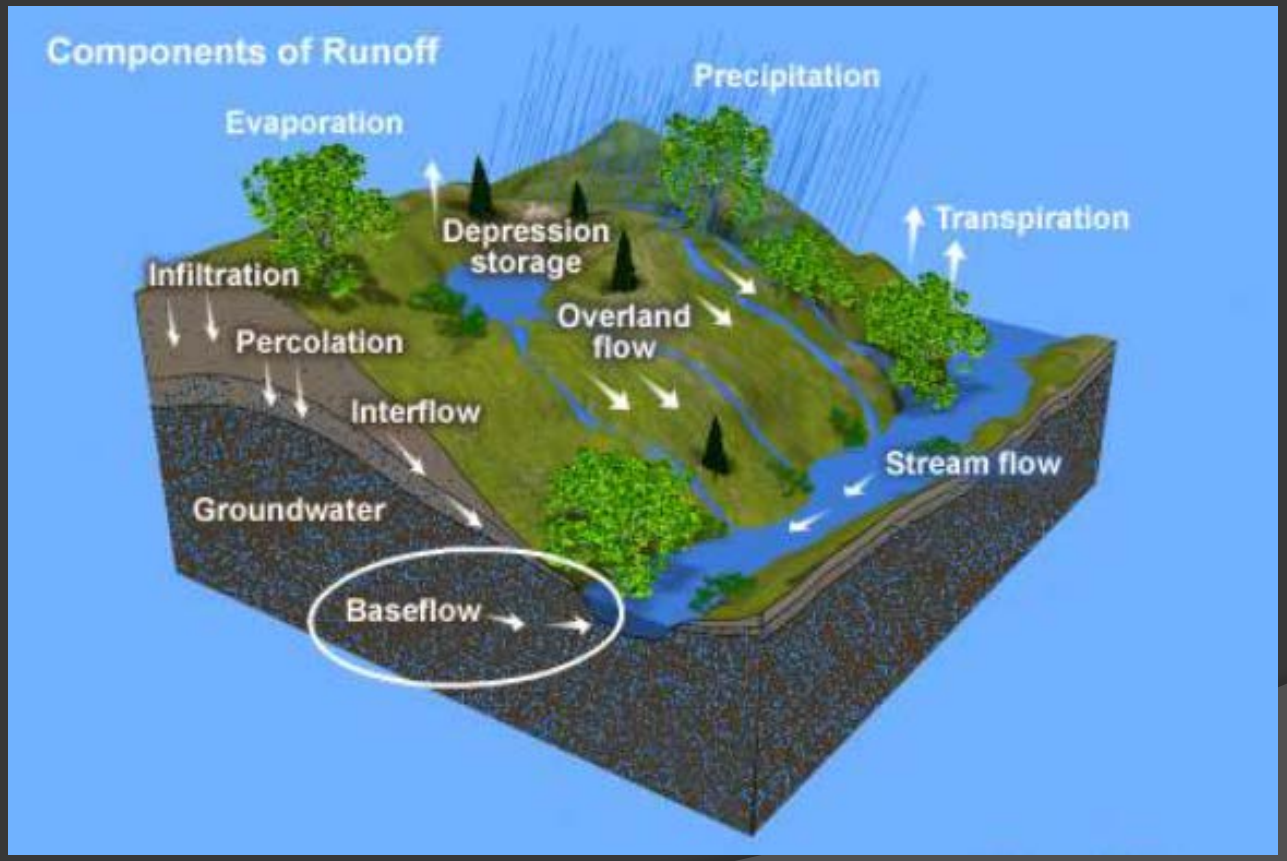
1) is the rainfall rate and the ability for the ground, rivers and streams to absorb the water and

2) the amount of water that is already stored in the ground or moving through the rivers and streams.

Hydrologic modeling of flash floods includes information on:

Hydrological process including components of the hydrologic cycles, rainfall-runoff processes, evaporation, infiltration and groundwater flow, water budgets, surface and sub-surface hydrology.

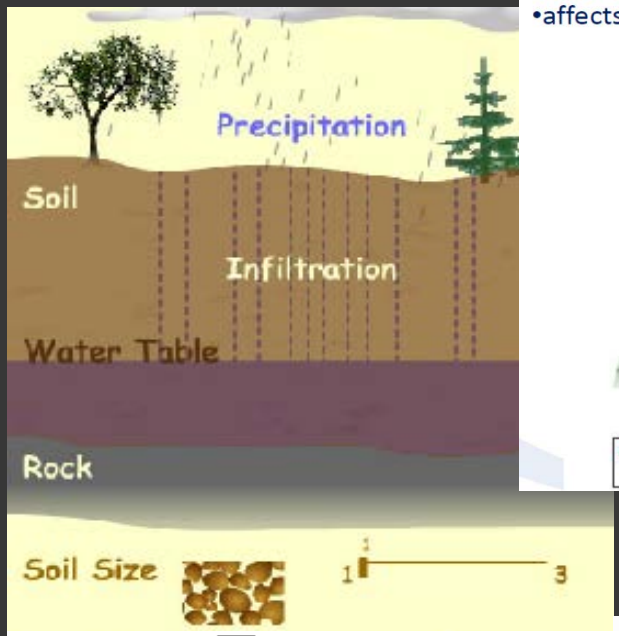
Volume = inflow – outflow of a system



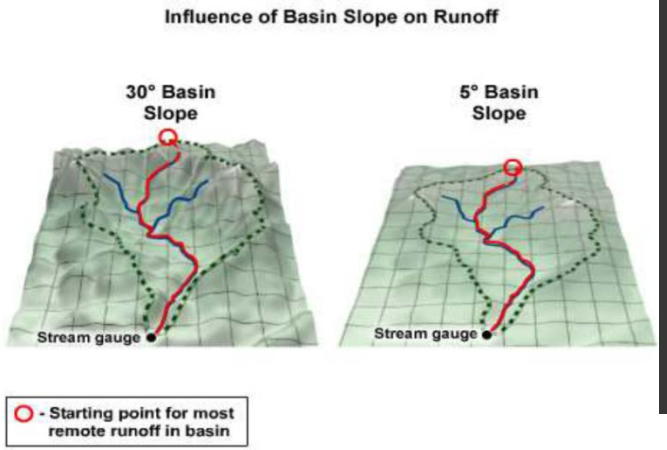
THIS IS KEY INFORMATION FOR FLOOD AND FLASH FLOOD FORECASTING

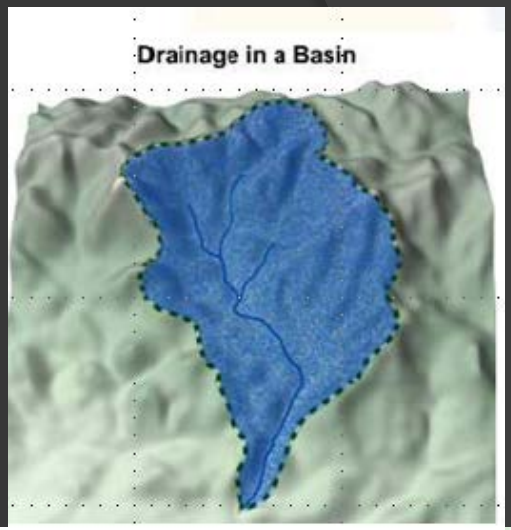
Hydrologic modeling of flash floods includes information on:

Also needed is information on stream flow data networks, and detailed descriptions of the river basins, including vegetation types, soil types, topography, basin size, shape, slope.

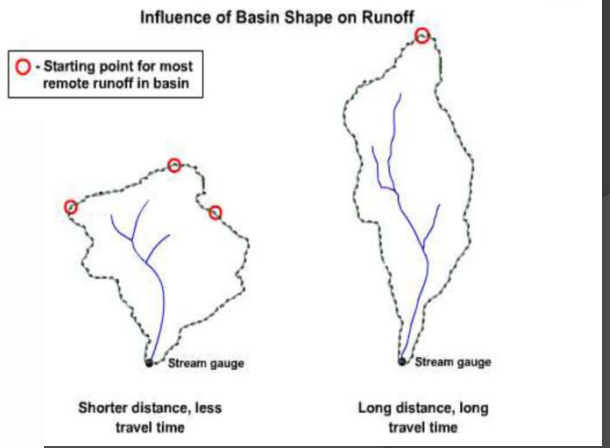


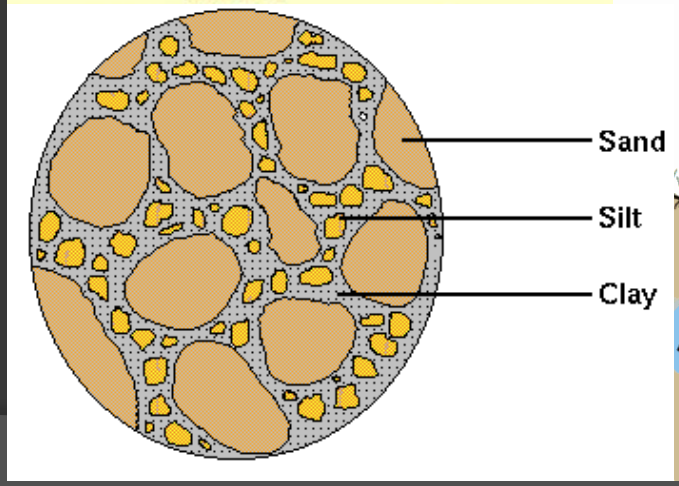
•affects amount and timing of runoff

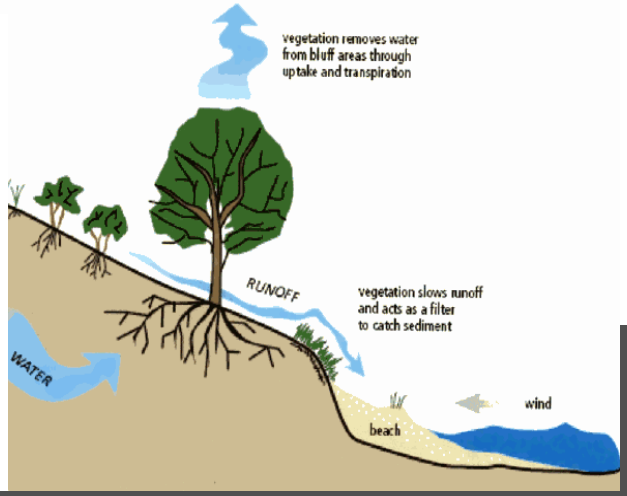




influences magnitude and timing of peak flow



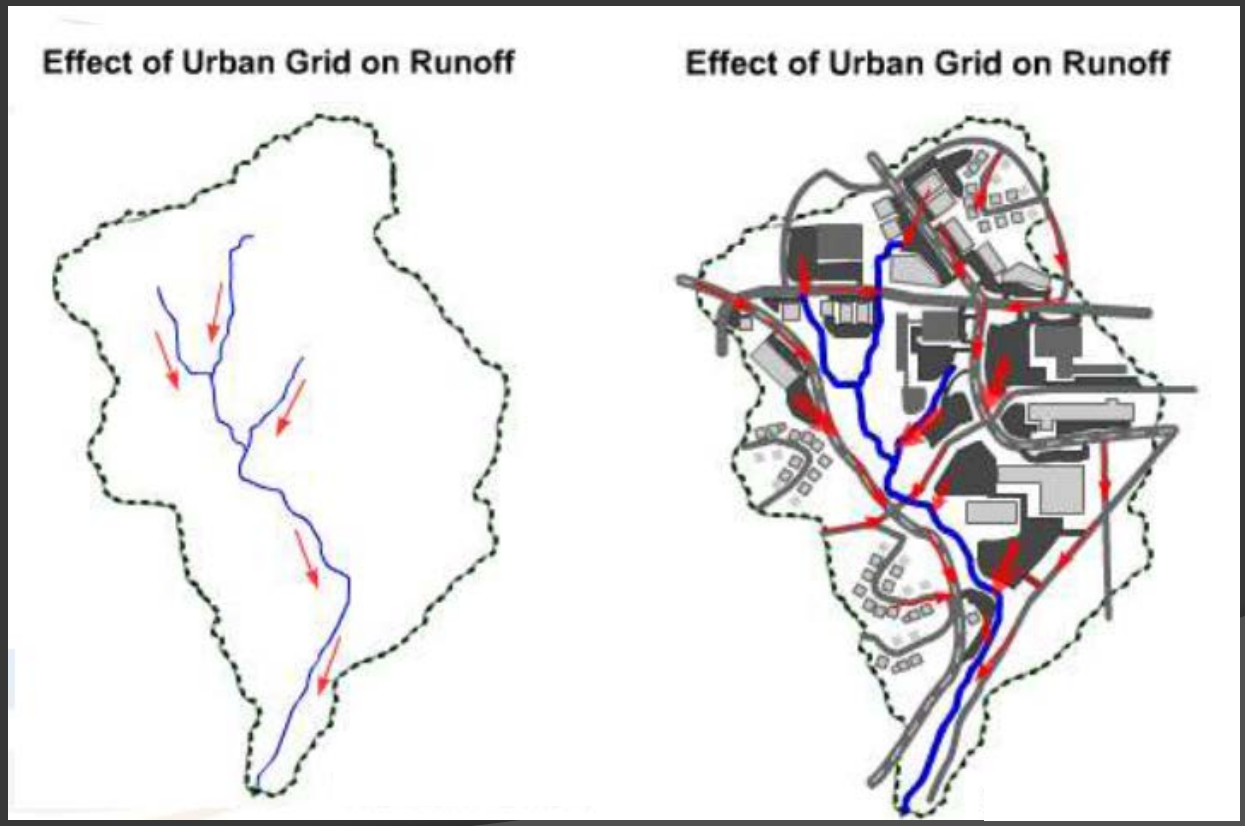




Urbanization

Results in changes of the natural ground surfaces and stream channels of the basin, permeability, roughness, etc.

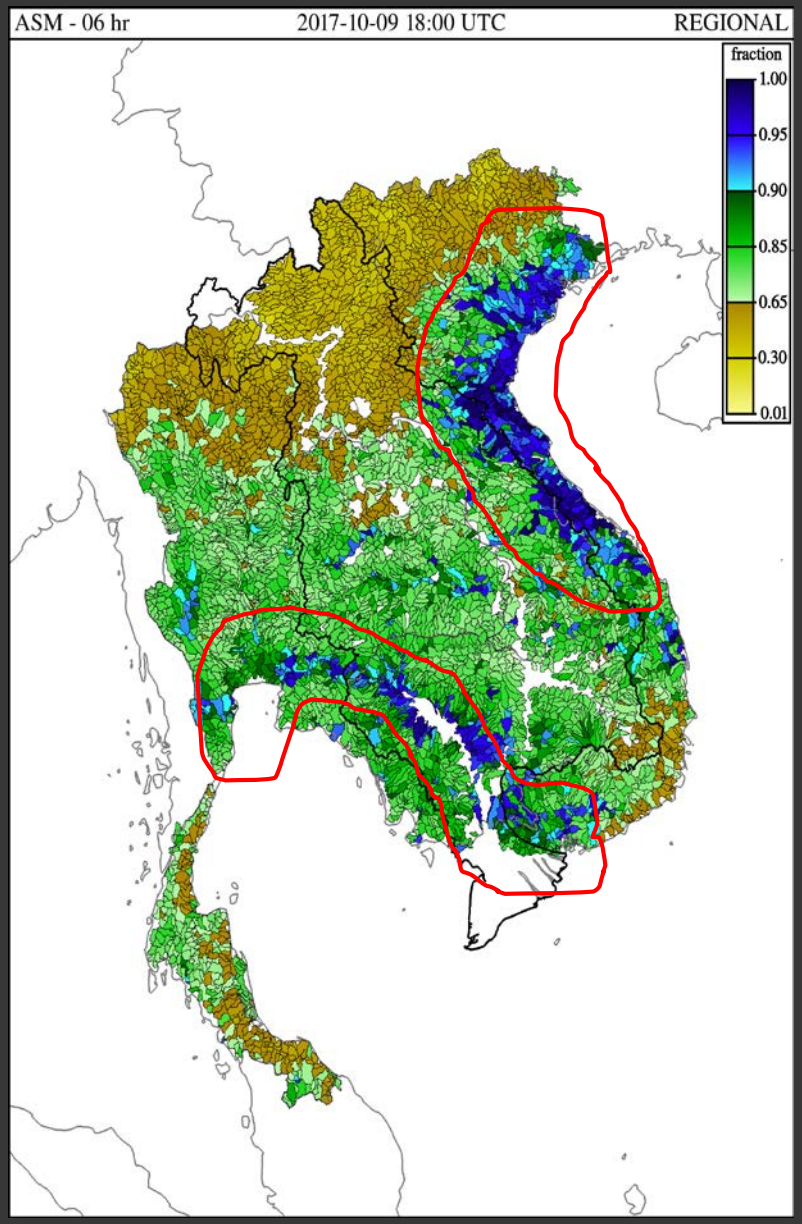
Road and storm sewer systems add to stream density, resulting in more rapid runoff to stream channels (also because of decreased roughness)



So in summary ……

Flash floods are phenomenon in which the important hydrologic processes are occurring on the same spatial and temporal scales as the intense precipitation.

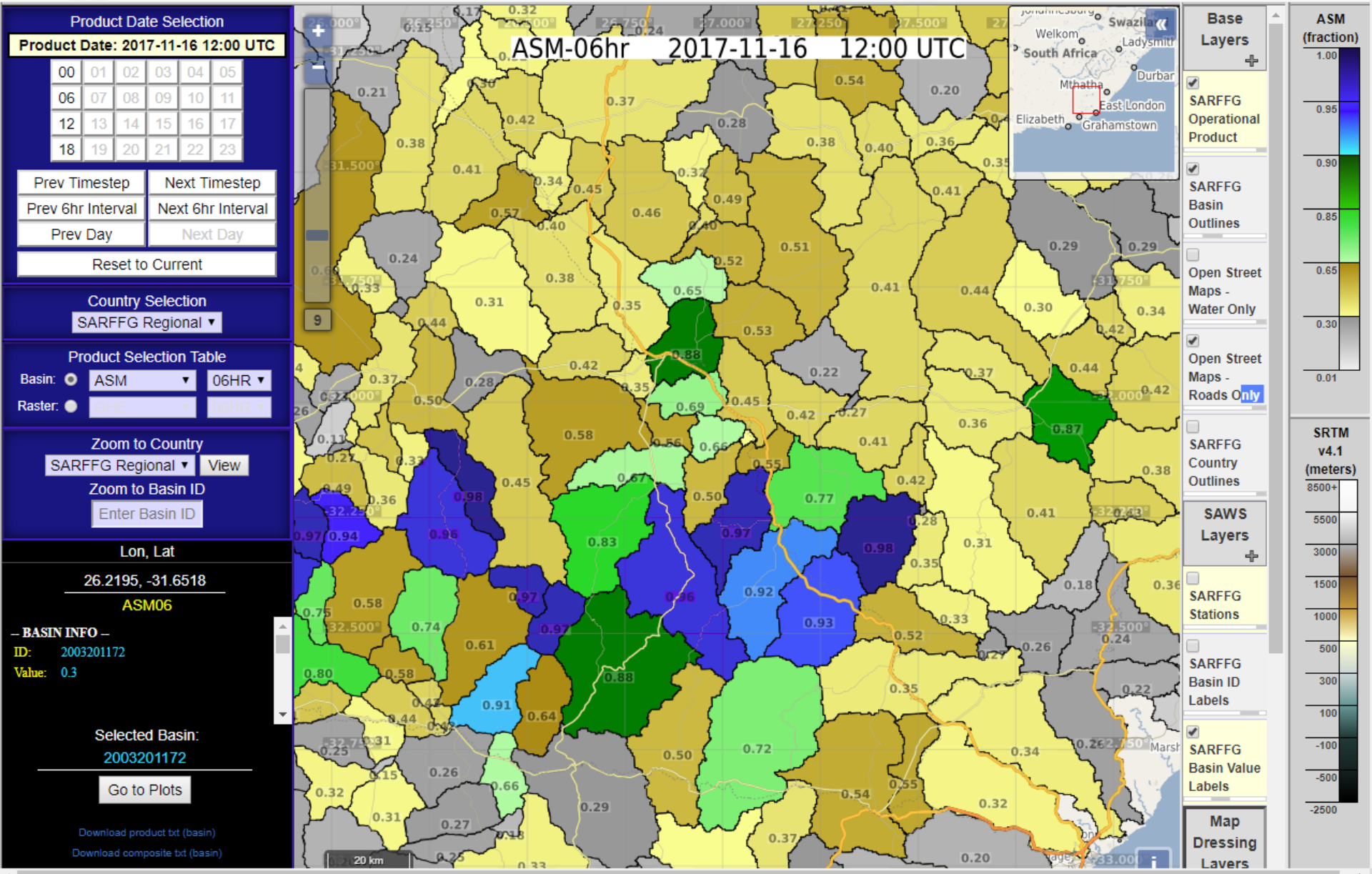
These include components of the hydrologic cycle, rainfall-runoff processes, evaporation, infiltration and groundwater flow, water budgets, surface and sub-surface hydrology, and properties unique to flash floods.



The flash flood guidance system offers products to assist forecasters

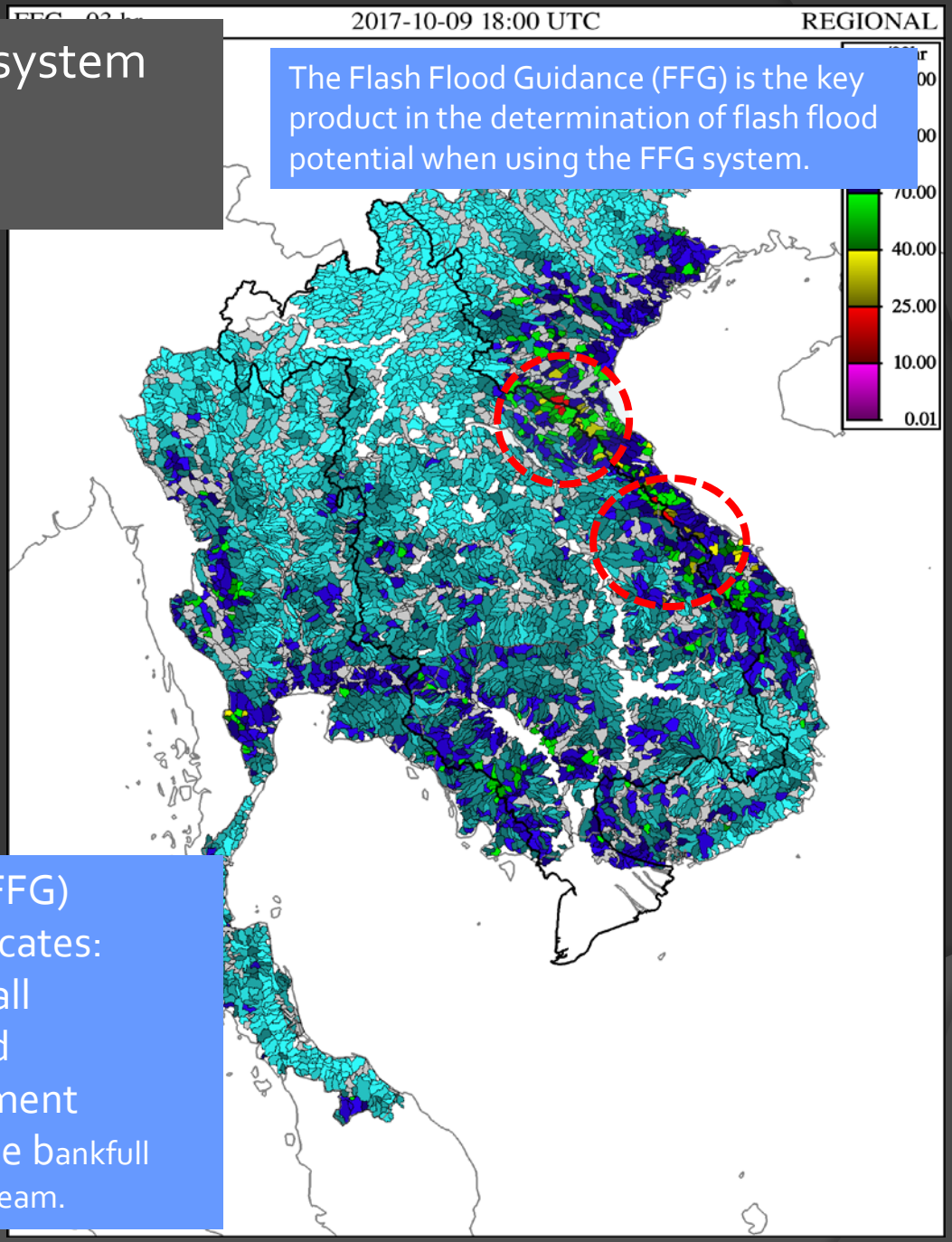
Average Soil Moisture (ASM) product provides soil water saturation fraction for the upper zone (about 20-30 cm depth) for each of the sub-basins.

Mapserver Interface Prototype



The flash flood guidance system offers products to assist forecasters

The Flash Flood Guidance (FFG) is the key product in the determination of flash flood potential when using the FFG system.

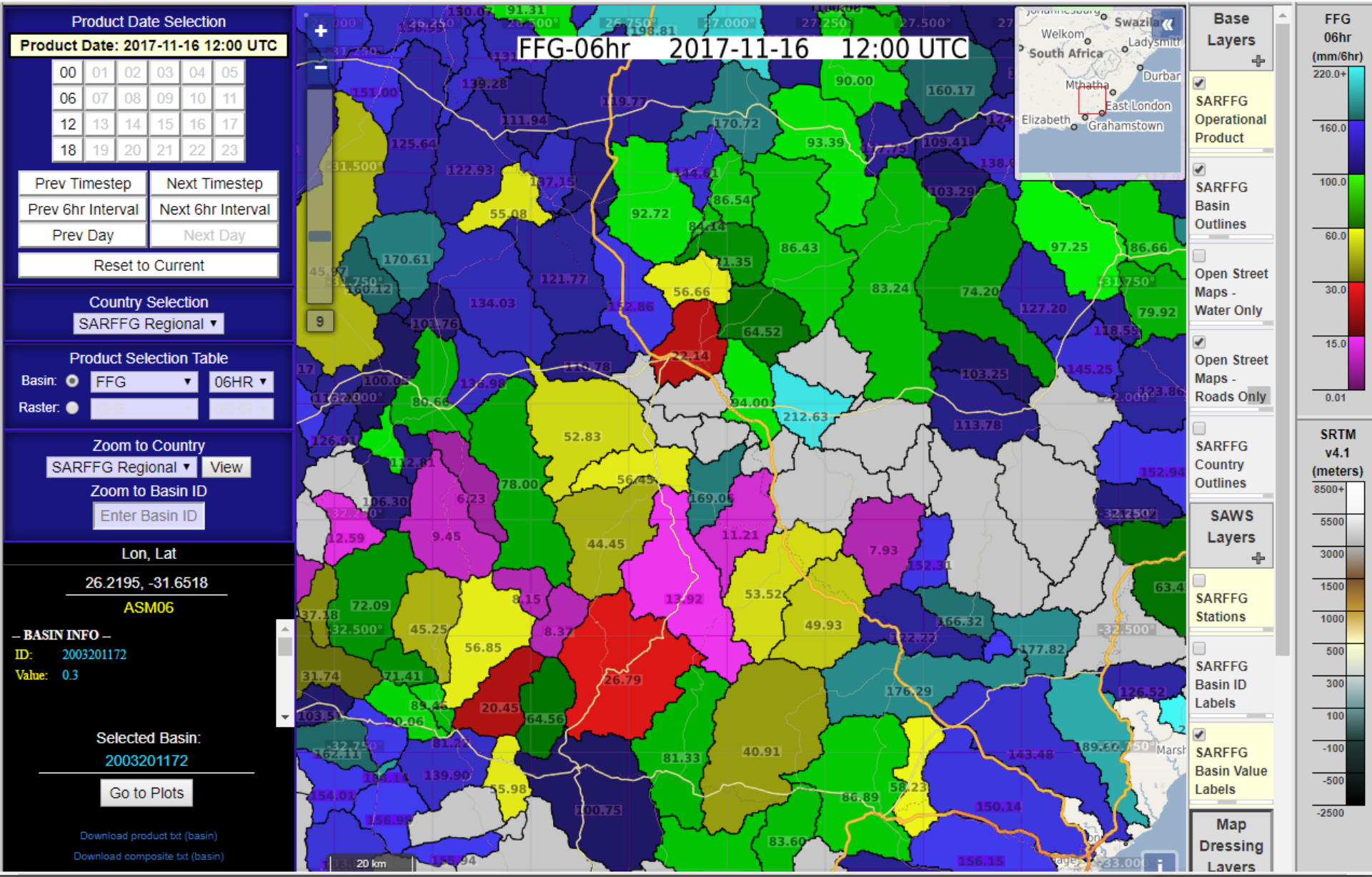


The Flash Flood Guidance (FFG) product is an index that indicates:

- the total volume of rainfall
- over a given duration and
- over a given small catchment

which is just enough to cause bankfull flow at the outlet of the draining stream.

Mapserver Interface Prototype



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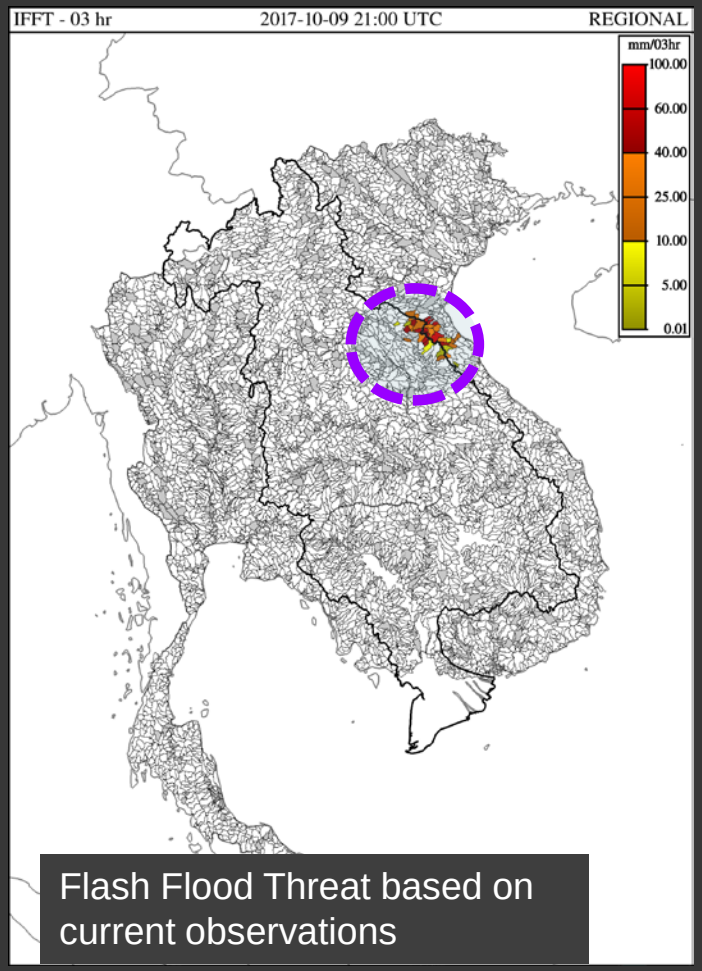
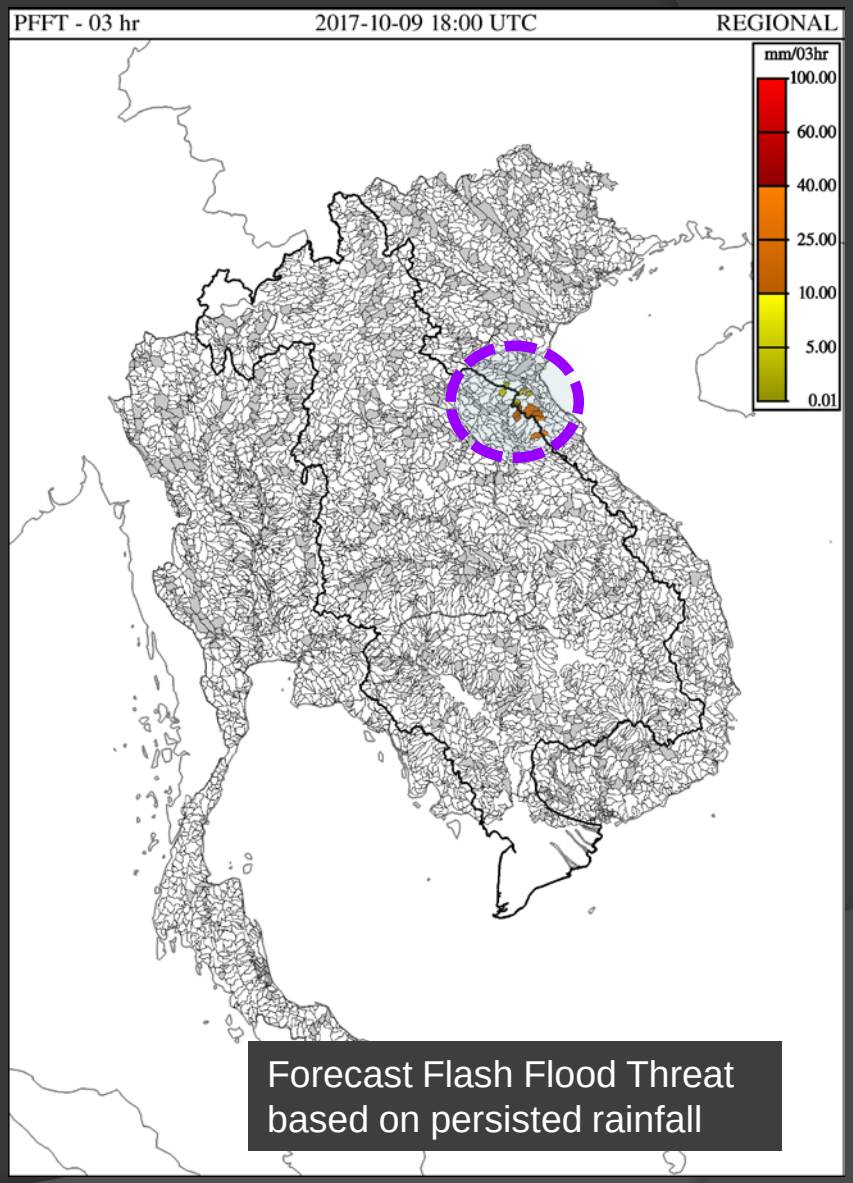
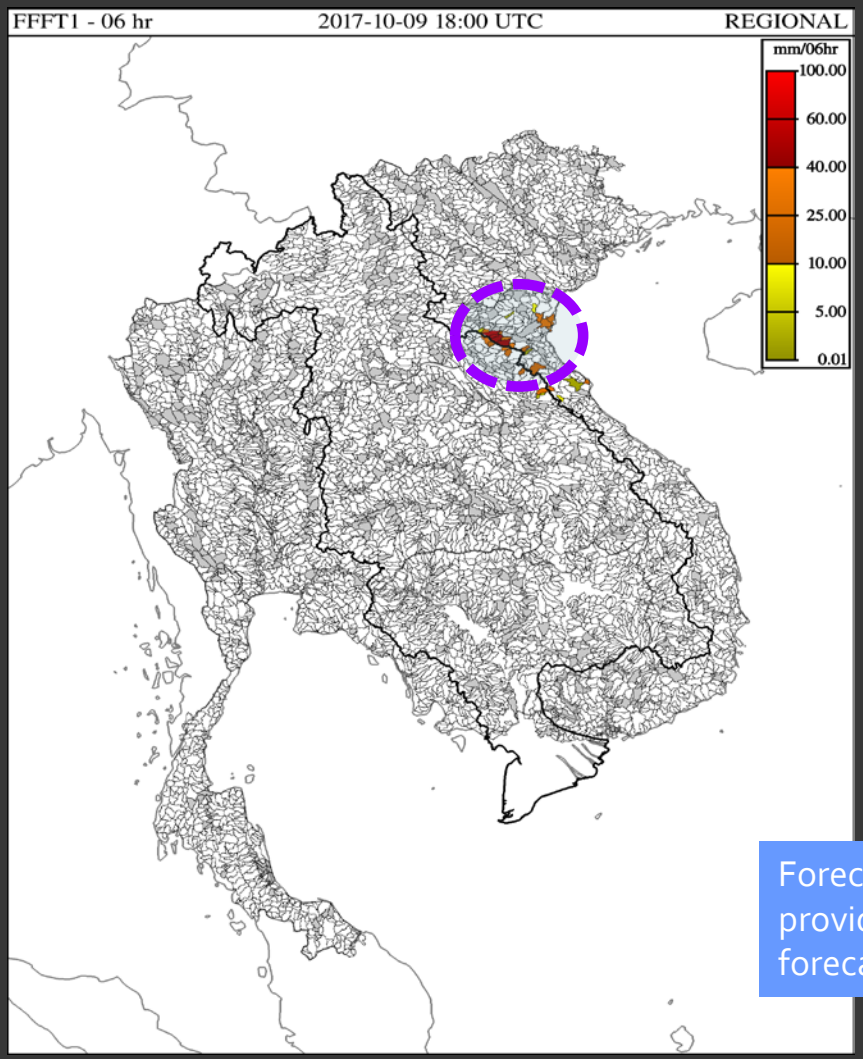


Flash Flood Threat based on current observations

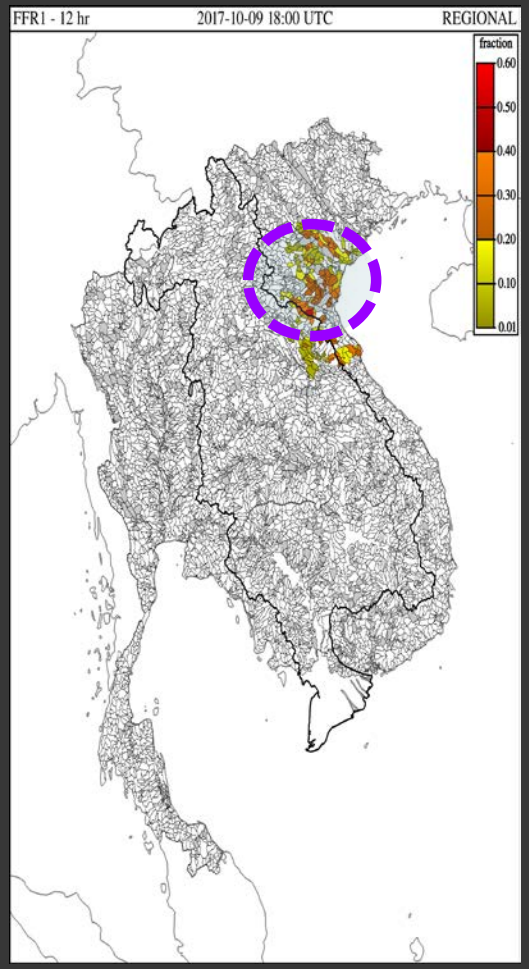


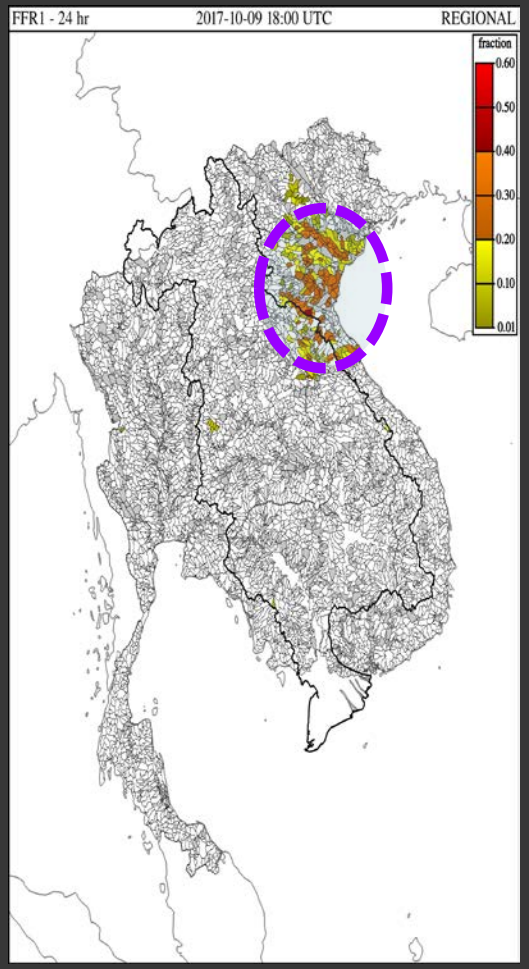
Forecast Flash Flood Threat based on persisted rainfall

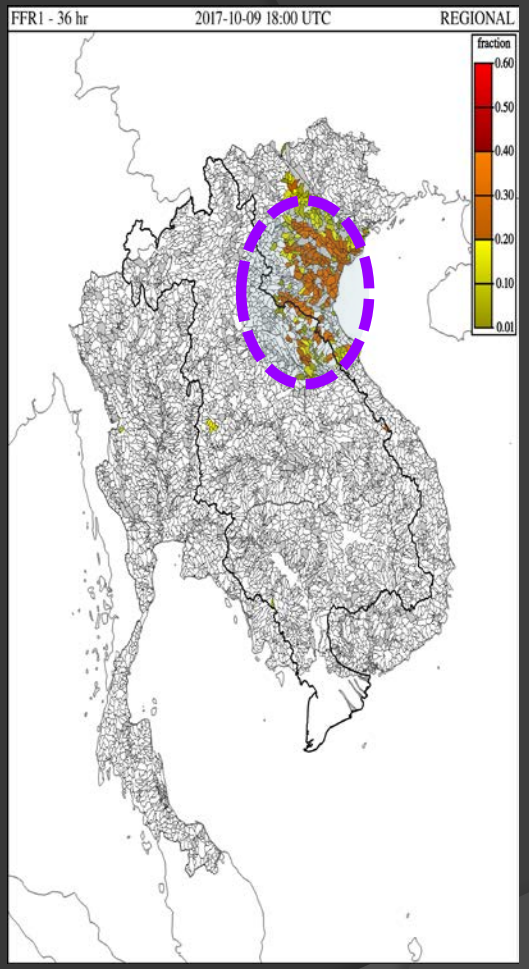
The flash flood guidance system offers products to assist forecasters



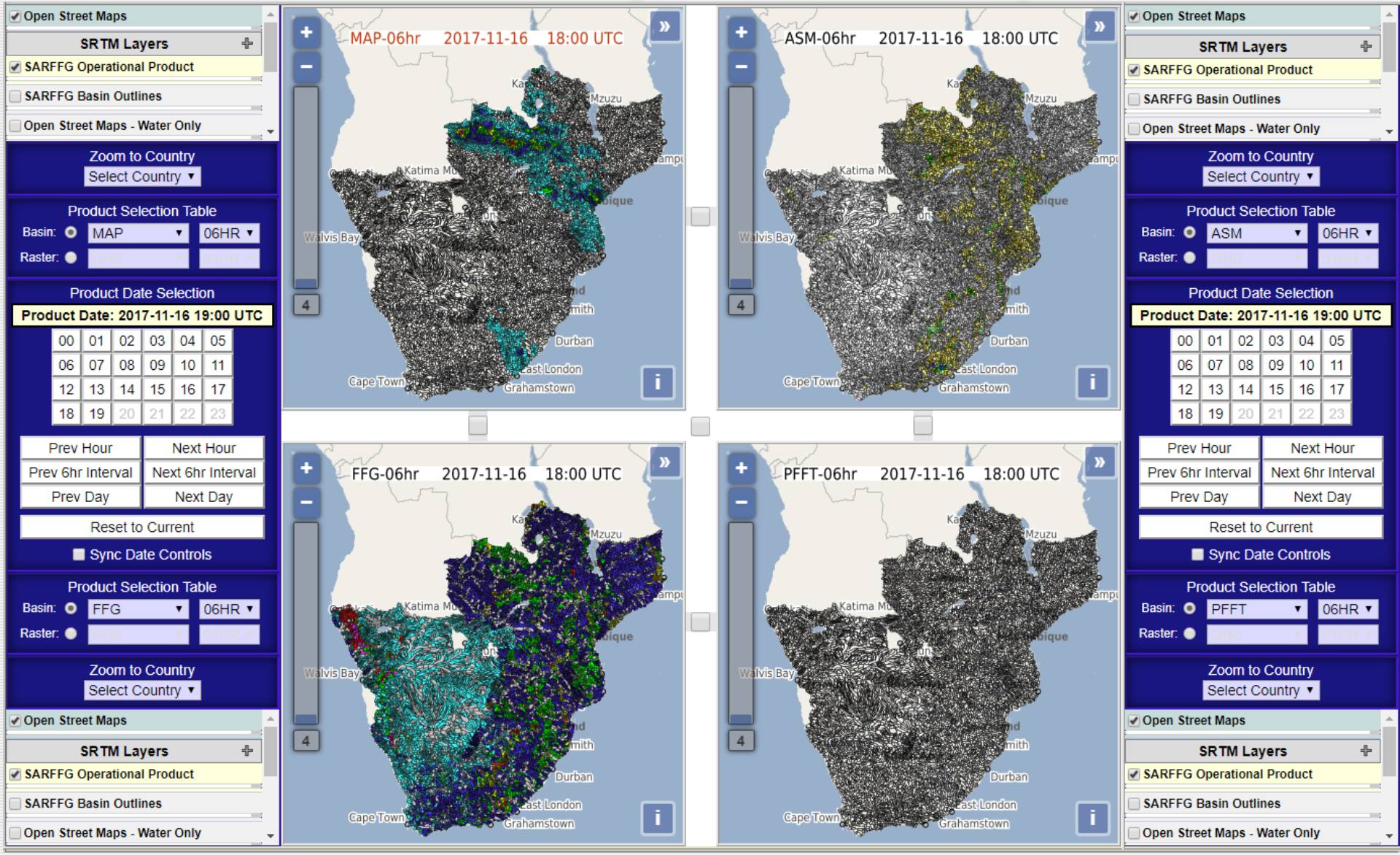
Forecast Flash Flood Threat (FFFT) Product provides the forecaster with an idea of regions forecasted to be of concern for flash flooding.







12, 24, and 36-hour Flash Flood Risk


Open Street Maps
SRTM Layers
SARFFG Operational Product
SARFFG Basin Outlines
Open Street Maps - Water Only
Zoom to Country
Select Country
Product Selection Table
Basin: MAP 06HR
Raster:
Product Date Selection
Product Date: 2017-11-16 19:00 UTC
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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
MAP-06hr 2017-11-16 18:00 UTC
ASM-06hr 2017-11-16 18:00 UTC
FFG-06hr 2017-11-16 18:00 UTC
PFFT-06hr 2017-11-16 18:00 UTC
Walvis Bay
Durban
Cape Town
East London
Grahamstown
Mzuzu

6. Forecasting Flash Floods

Flash Flood Forecasting

Flash floods are difficult to forecast:

- **Combination of high rainfall rate and**
- **Rapid and efficient runoff is common to flash flood events**

• Many countries warnings for flash floods: "heavy rain with potential for flash floods"

• Ignore underlying hydrological conditions, so there is a need to know accurately the rainfall rate over a river basin

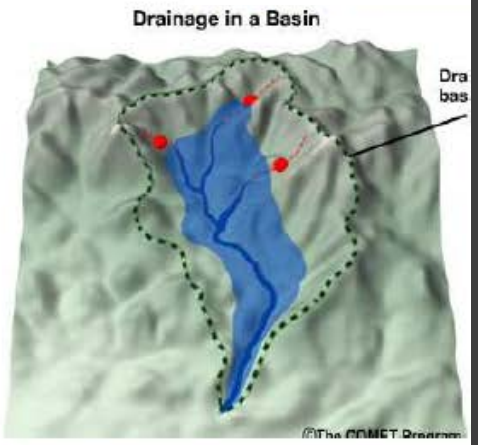
• Compared to a river flood, a flash flood is a true hydrometeorological problem

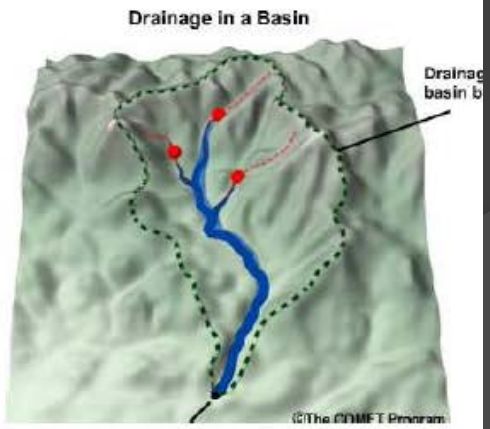
• Need for a meteorological & hydrological based flash flood forecasting system at time of flood to determine basins in danger

How do you predict a flash flood?

- Forecaster's question:
  - How much rain will cause a flood in this particular area?
- What do you need to know to answer this question?
  - How much water will run off?
  - How full is the stream?
  - What about recent rain?
  - ➢ How river basin responds - Hydrology
- How much rain am I expecting over this area?
  - ➢ Weather forecasting – Meteorology

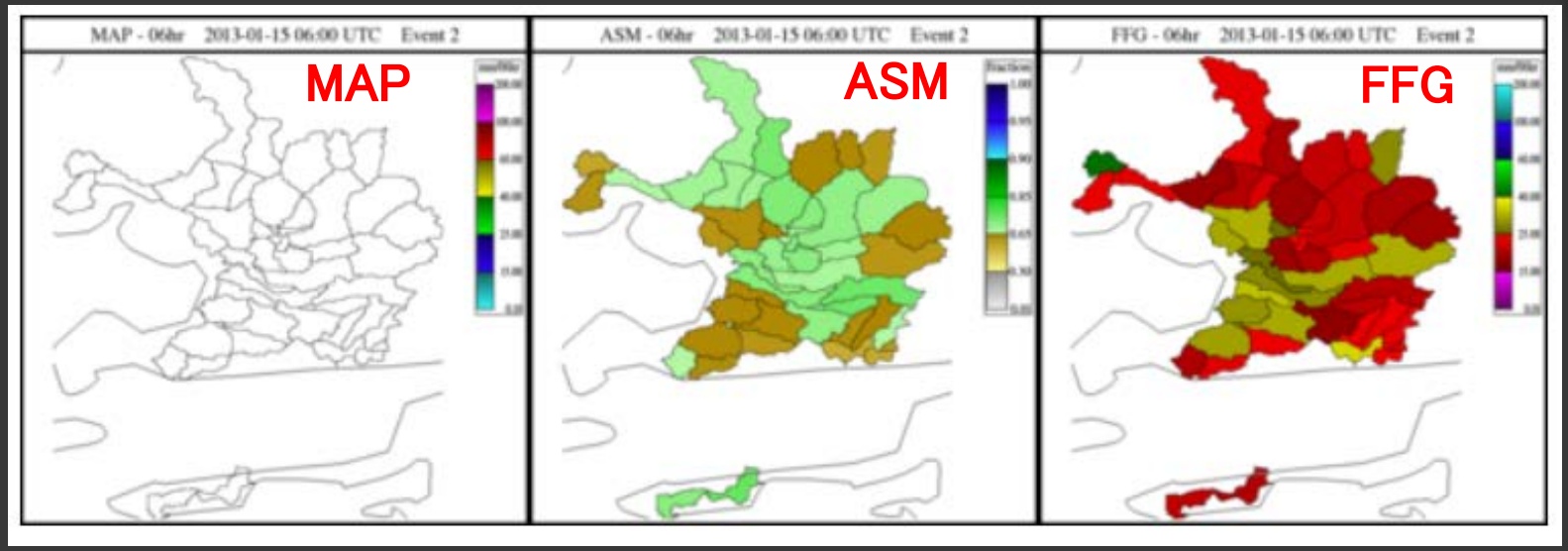
= Hydro-meteorological problem



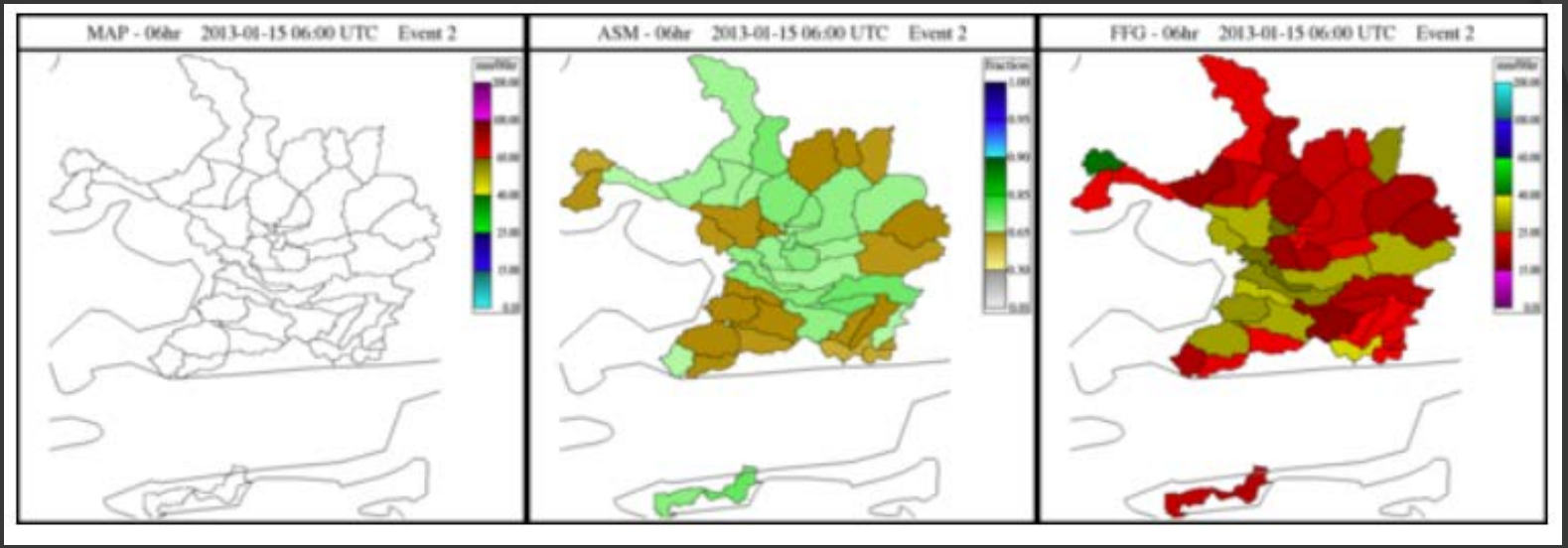


Flash Floods

A flash flood is a rapid onset flood (<6 hours) following the causative event (heavy rain, dam failure) "*too much water, too little time*"



Three of the flash flood guidance system products forecasters use to forecast flash floods



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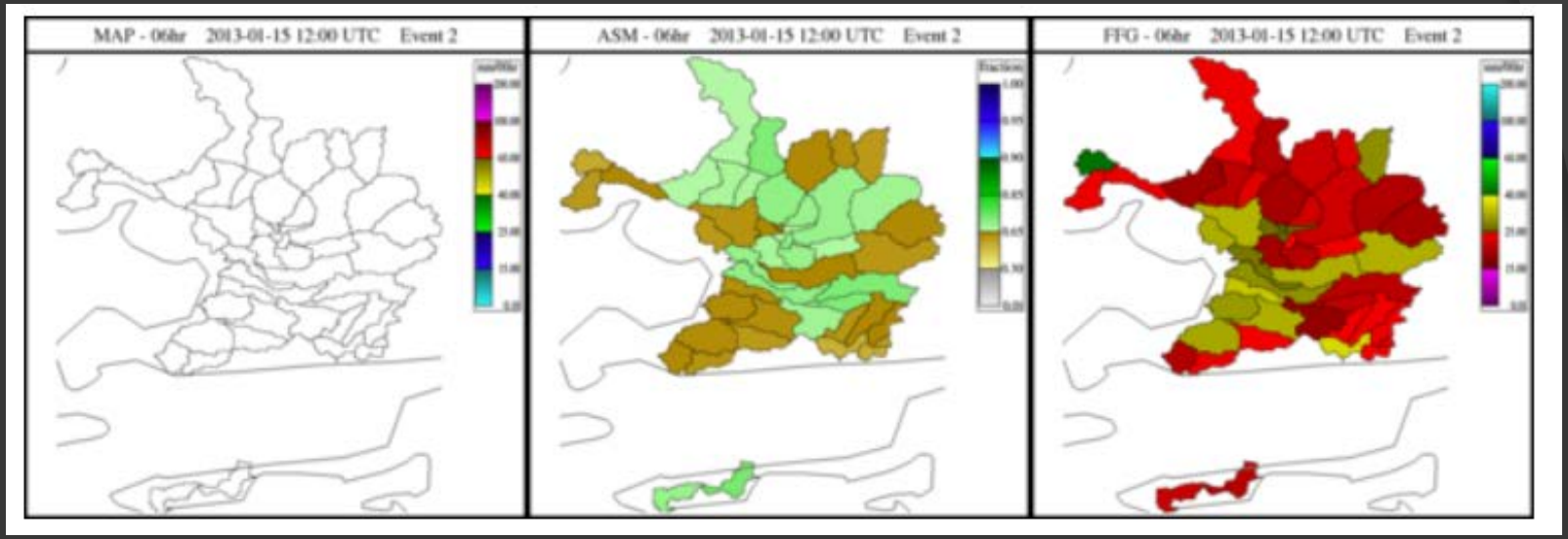

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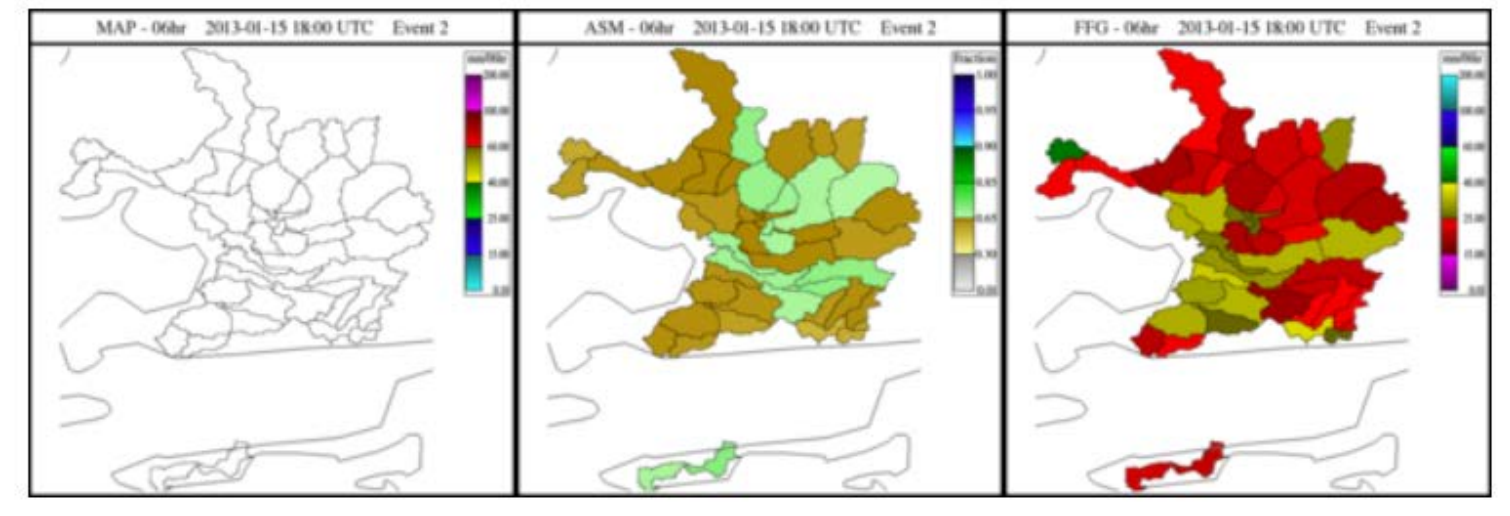

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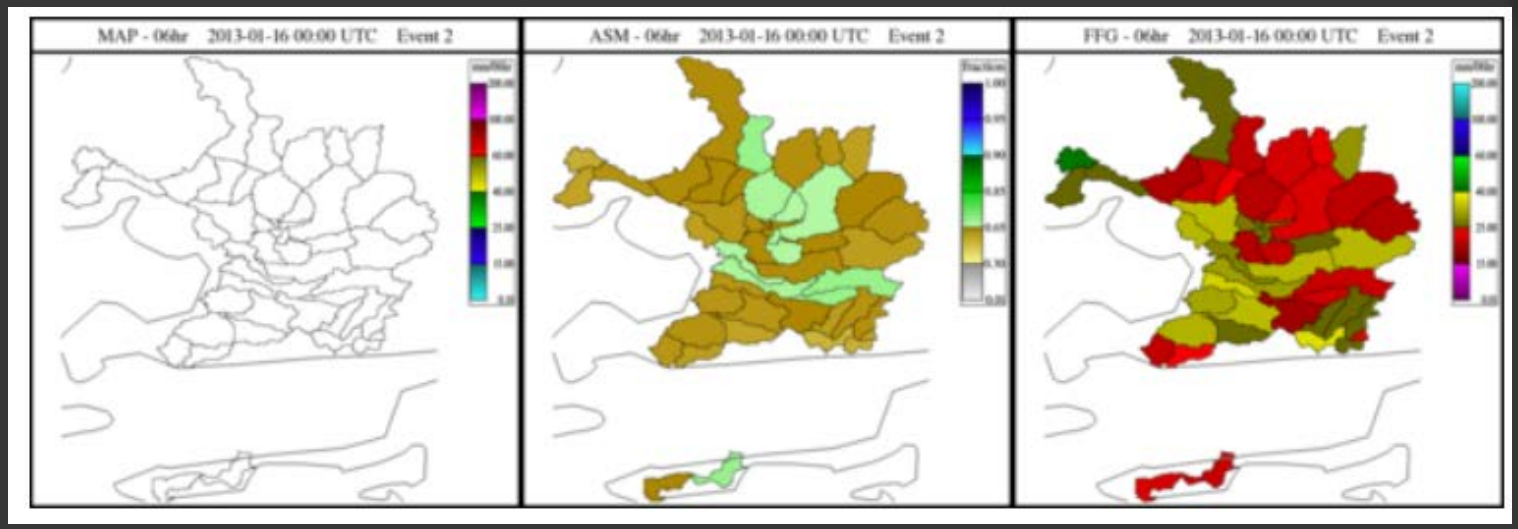

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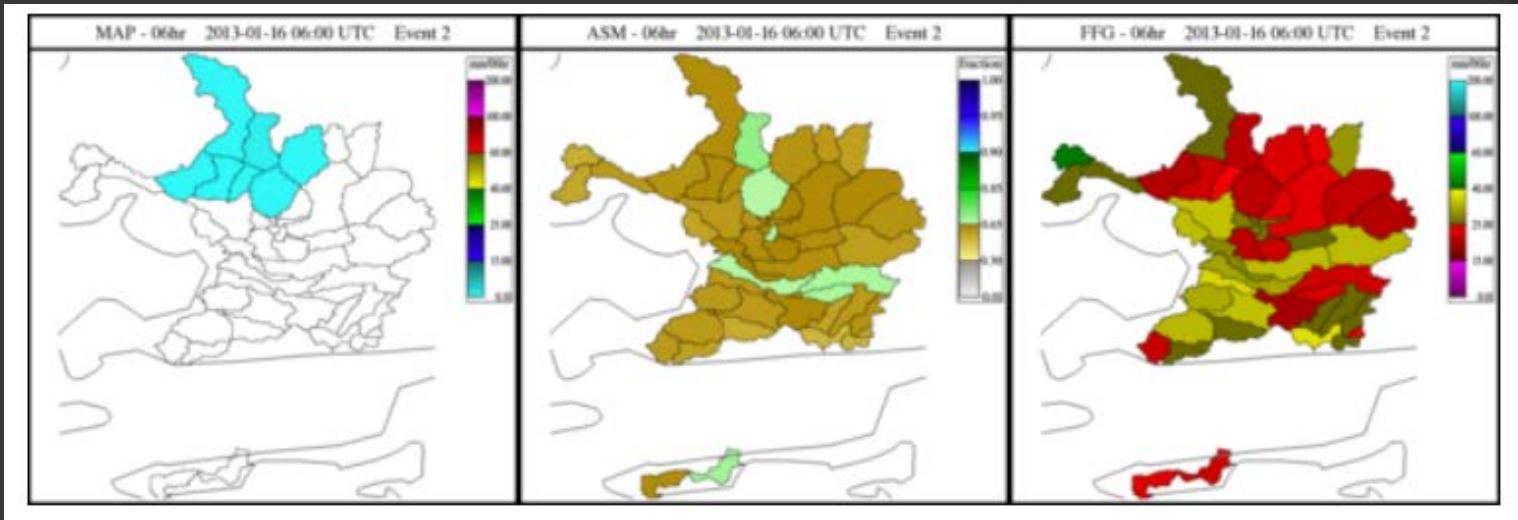

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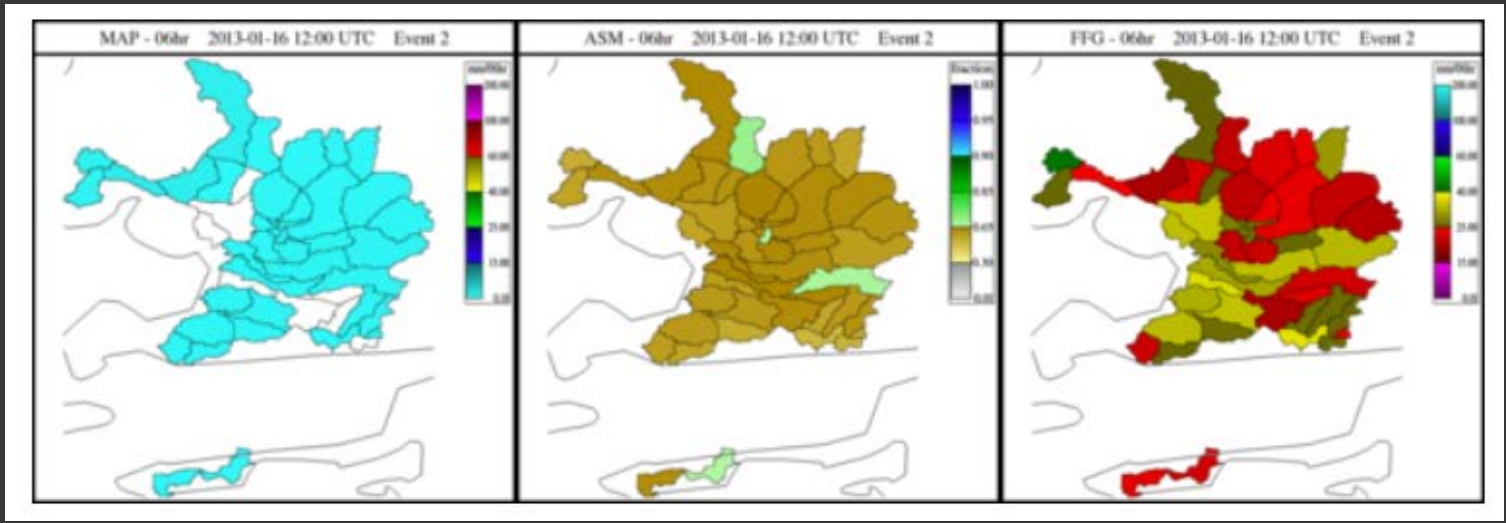

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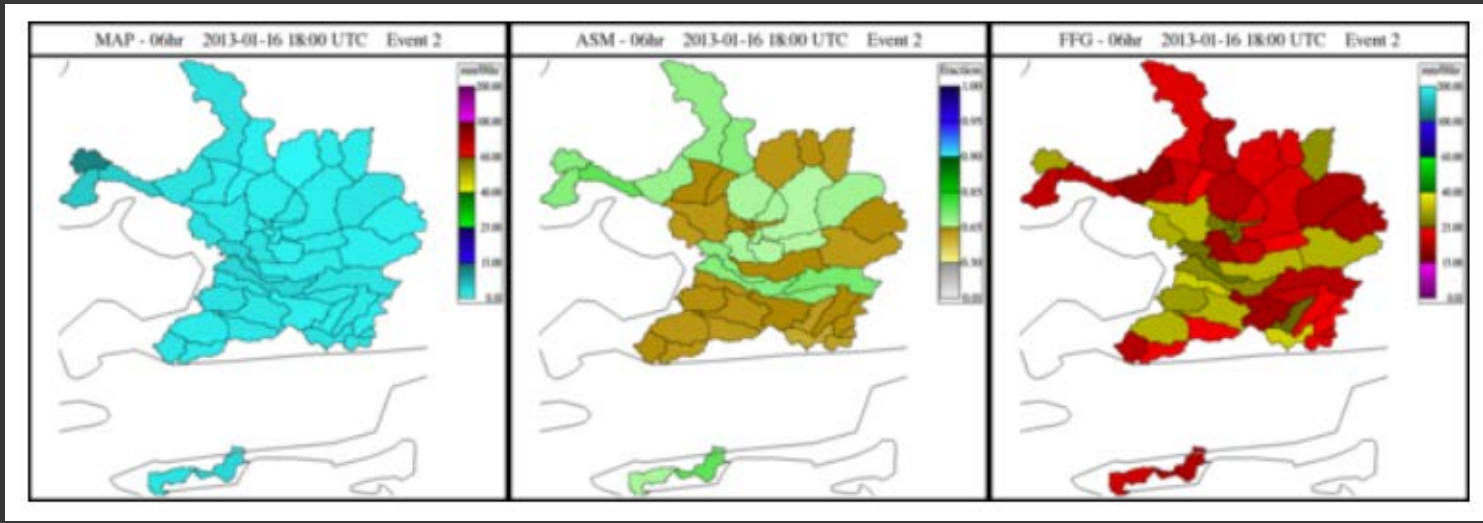

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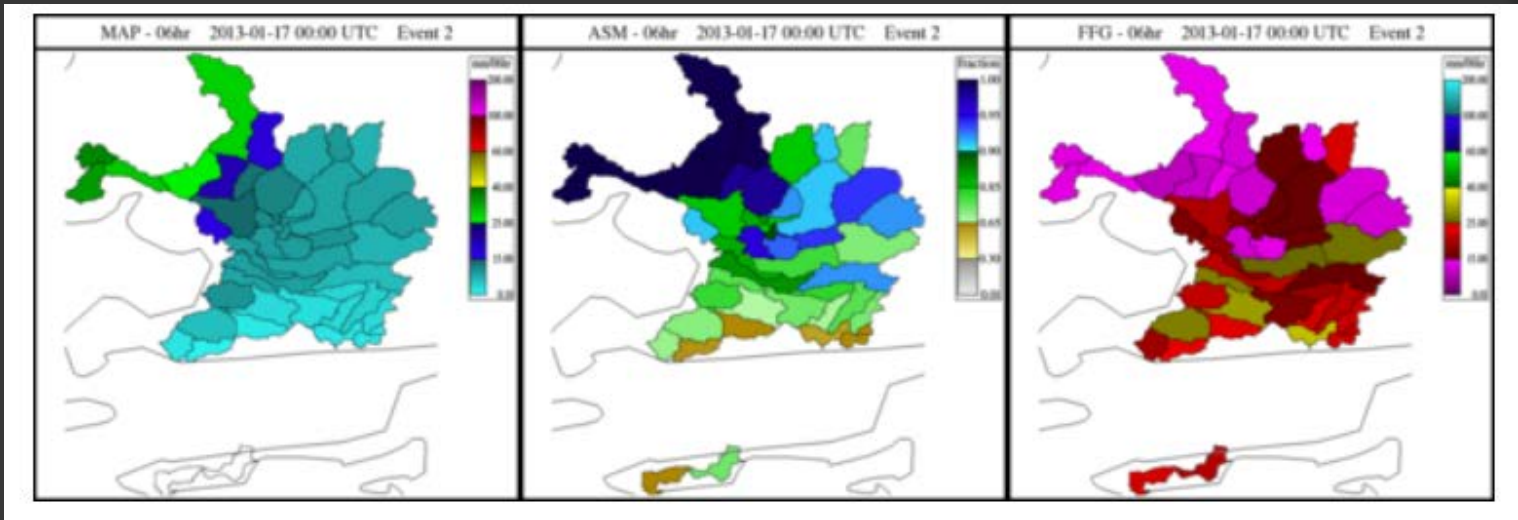

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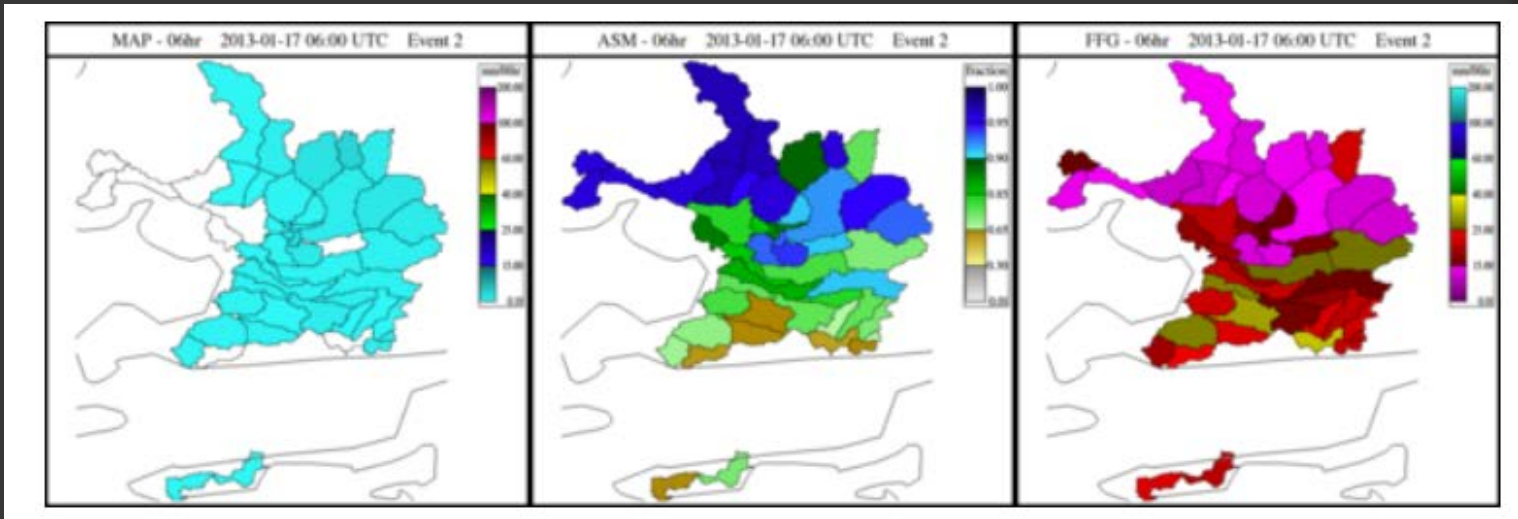

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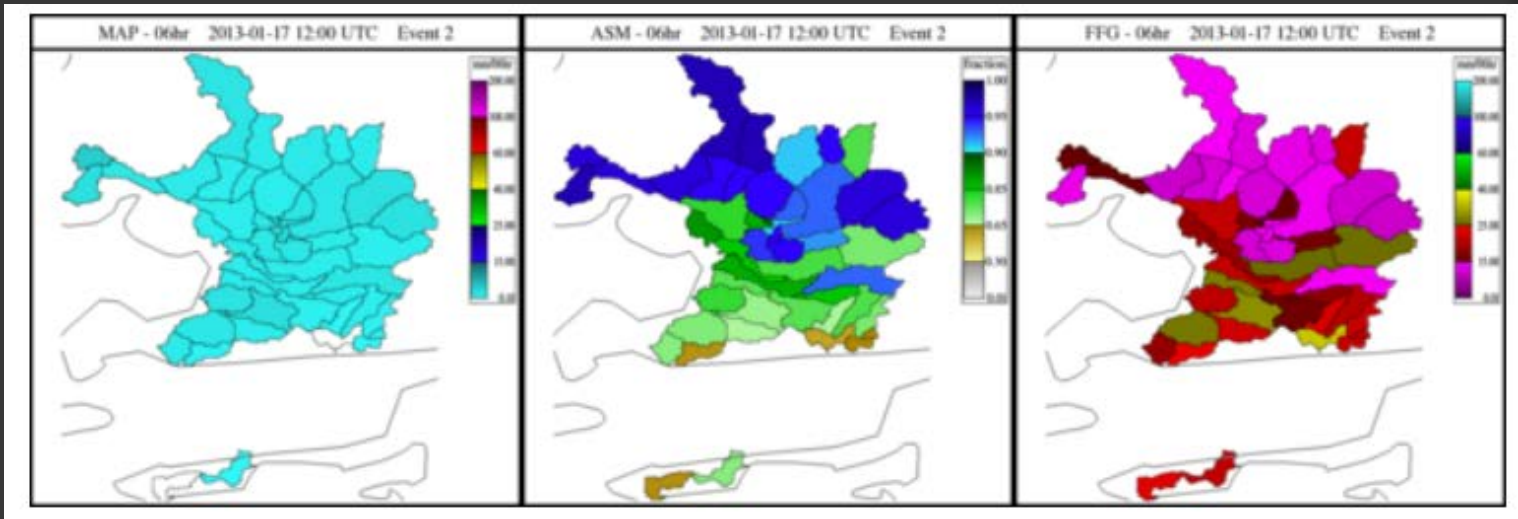

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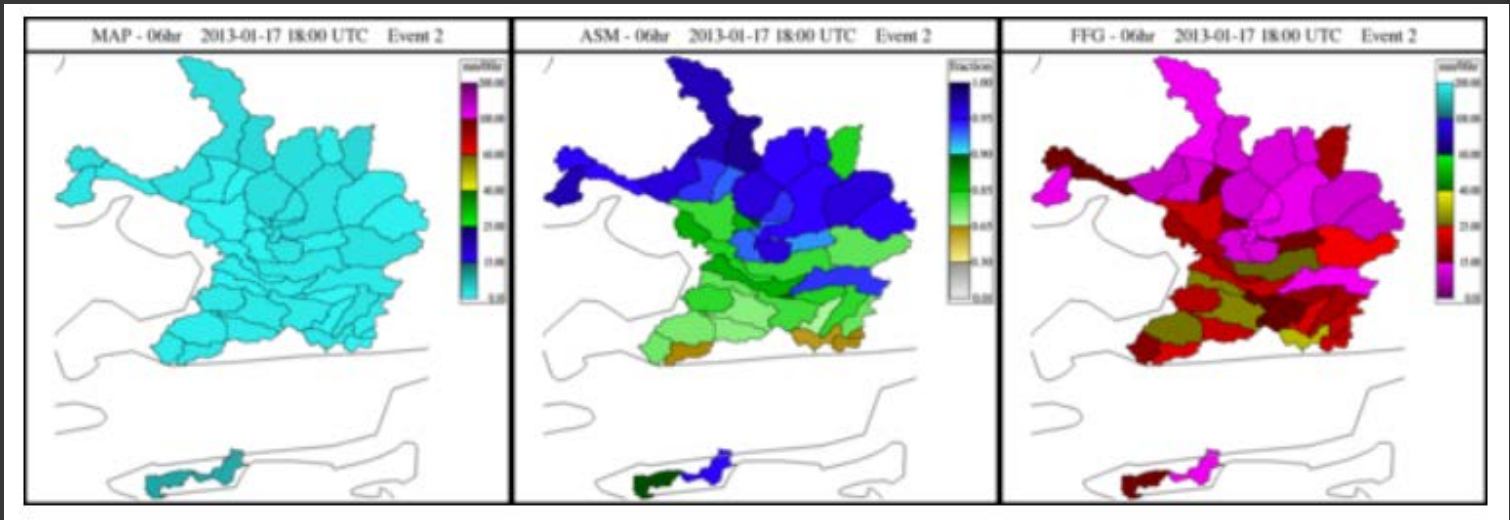

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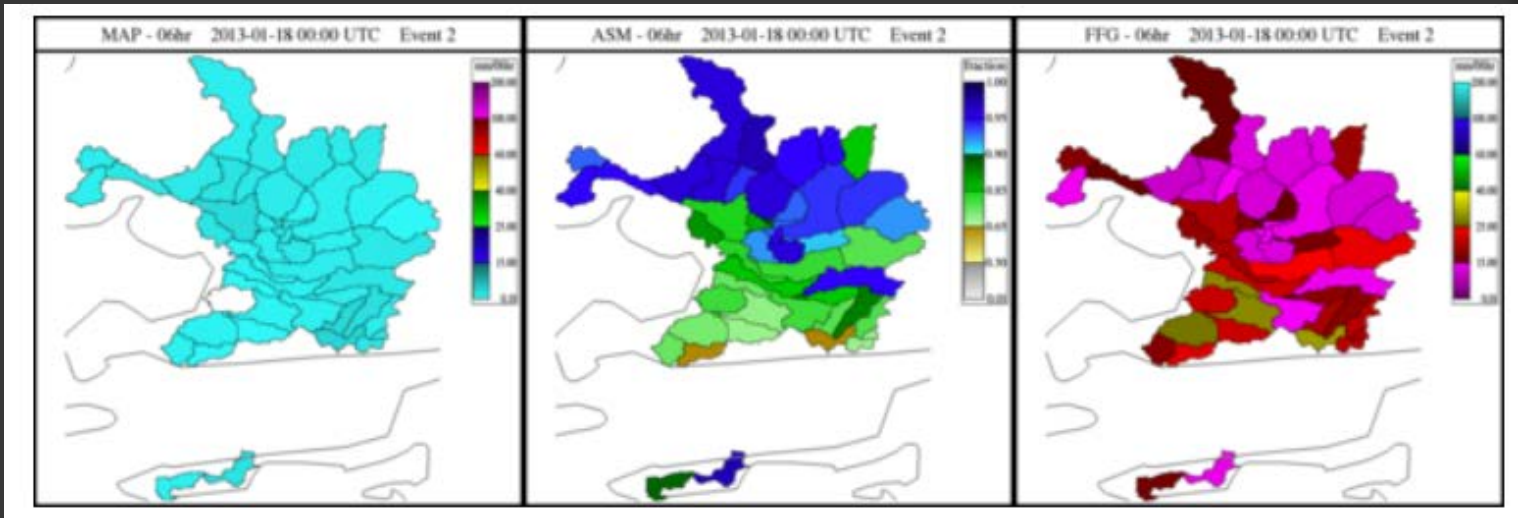

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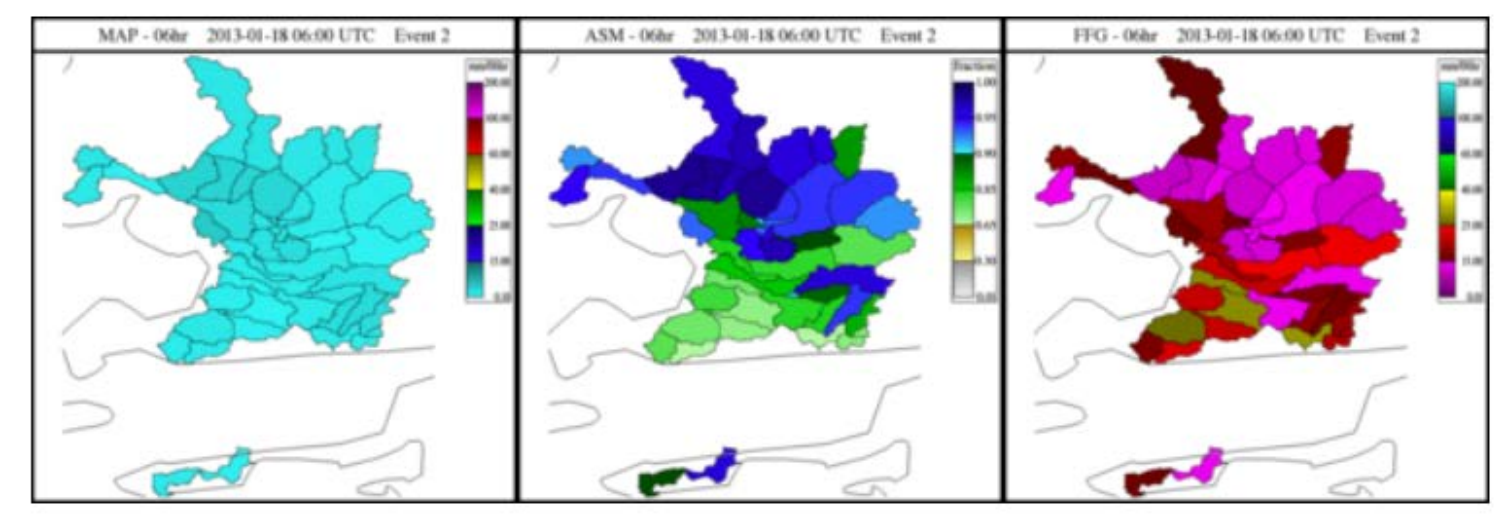

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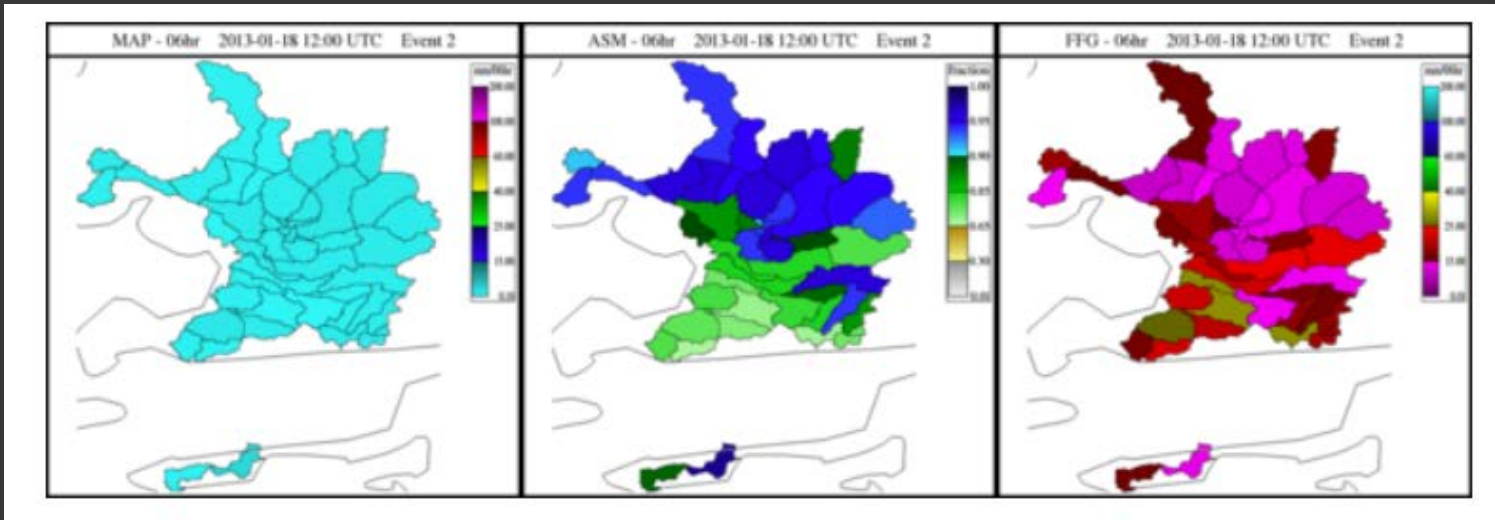

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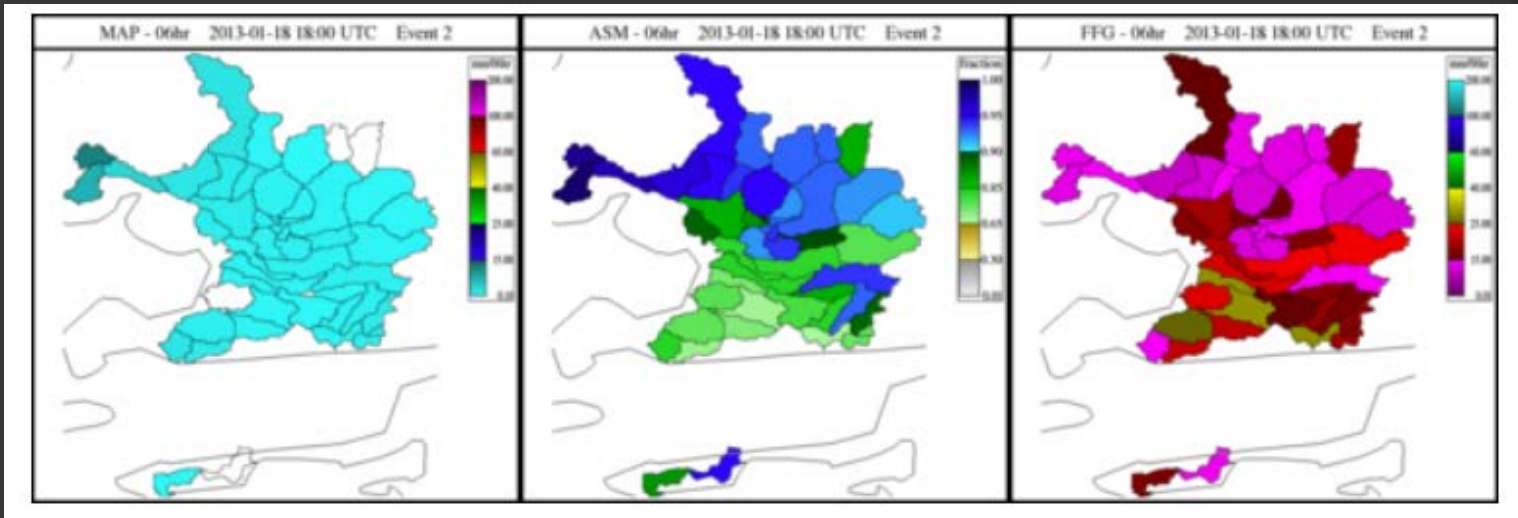

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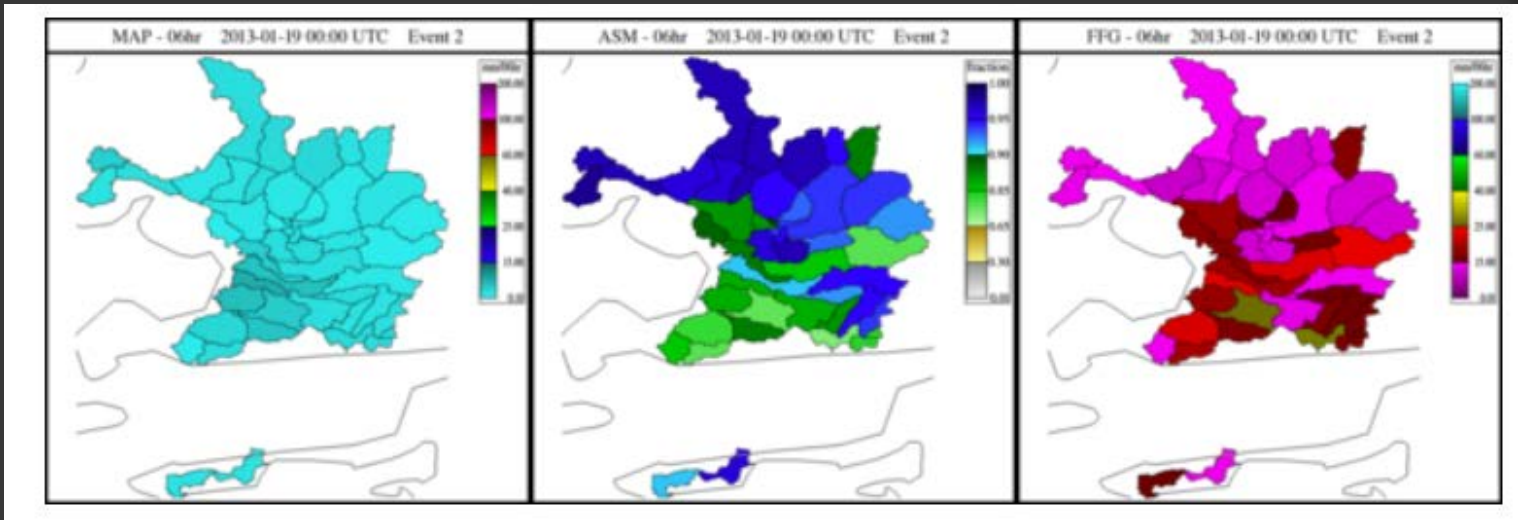

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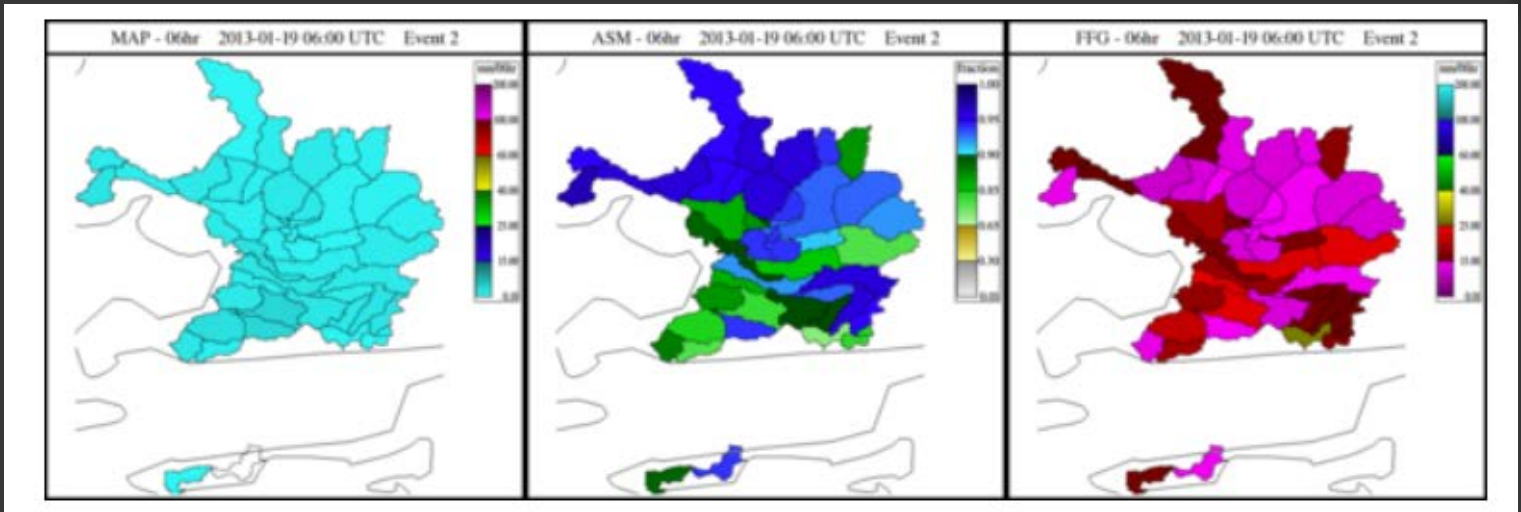

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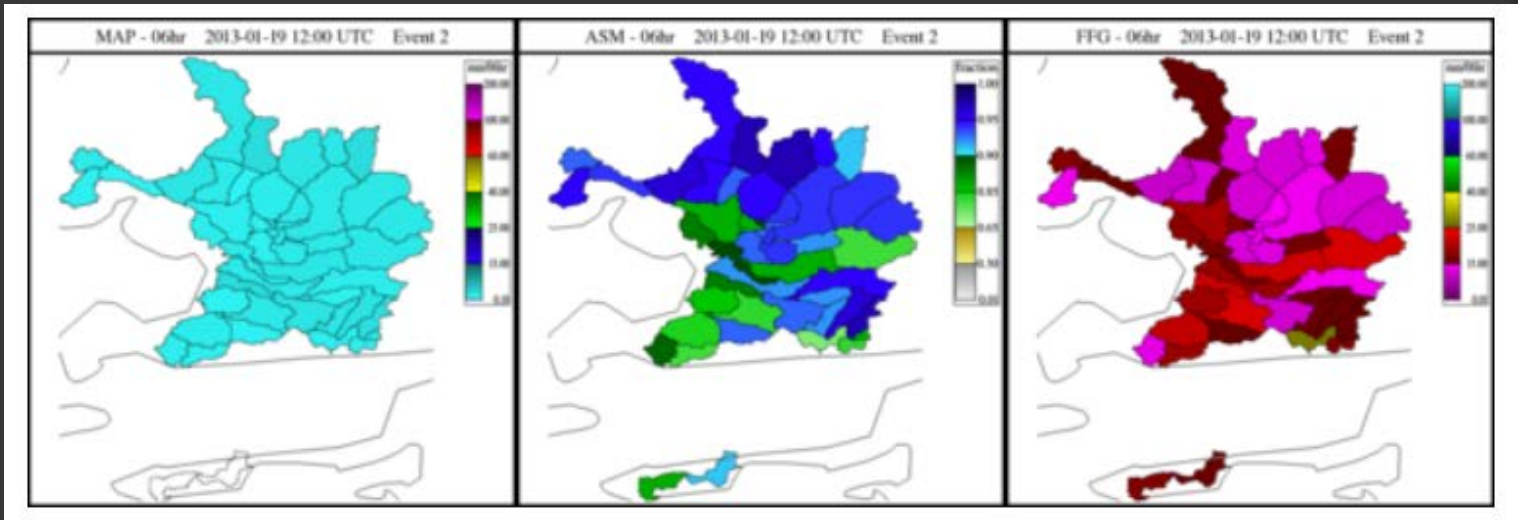

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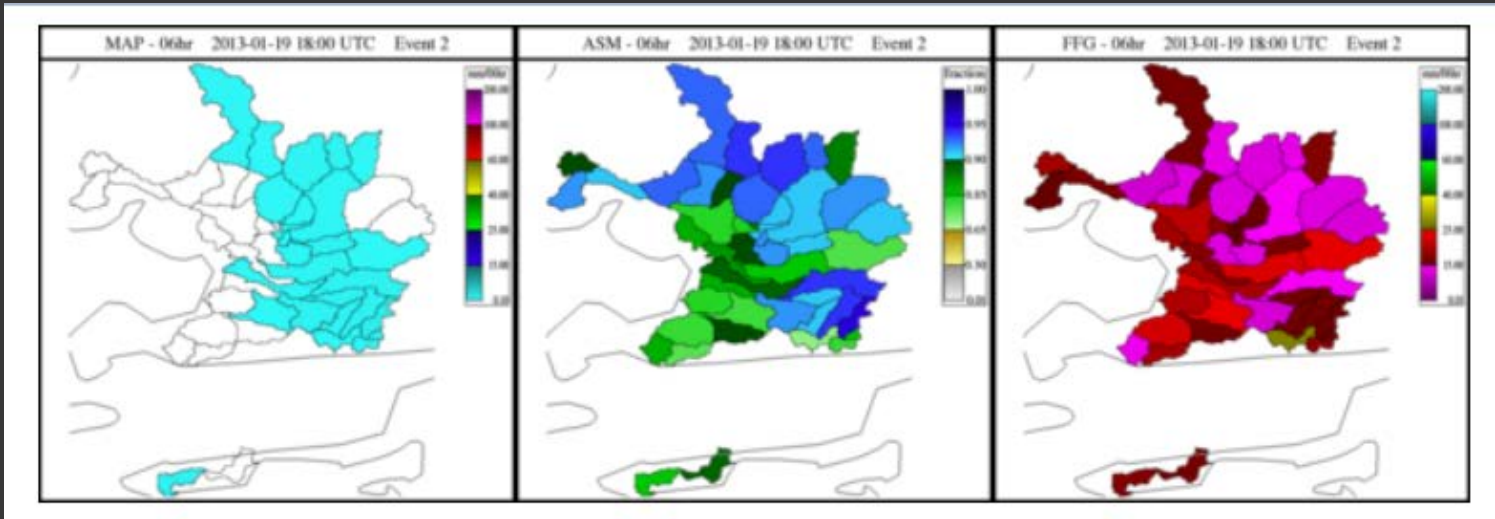

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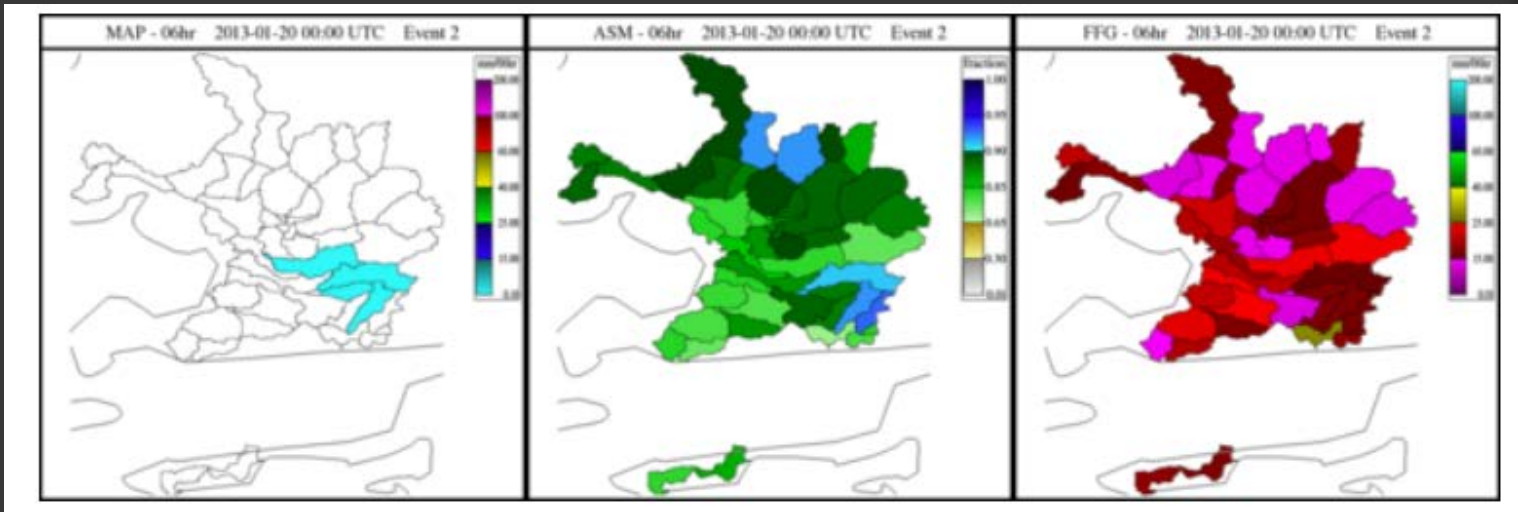

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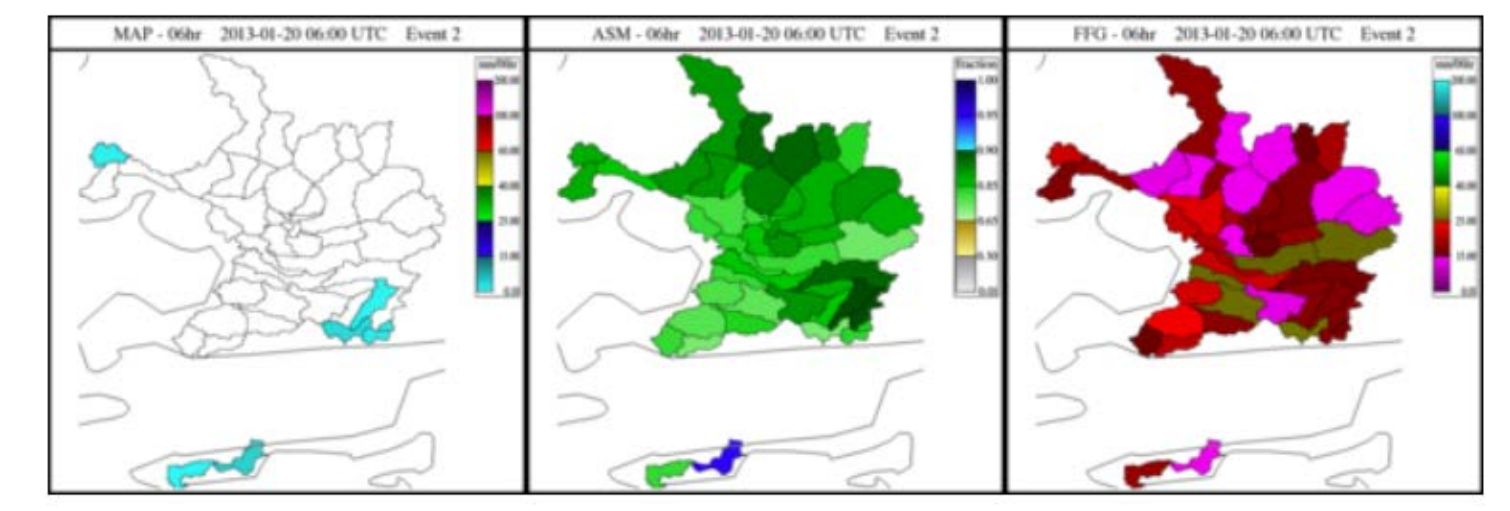

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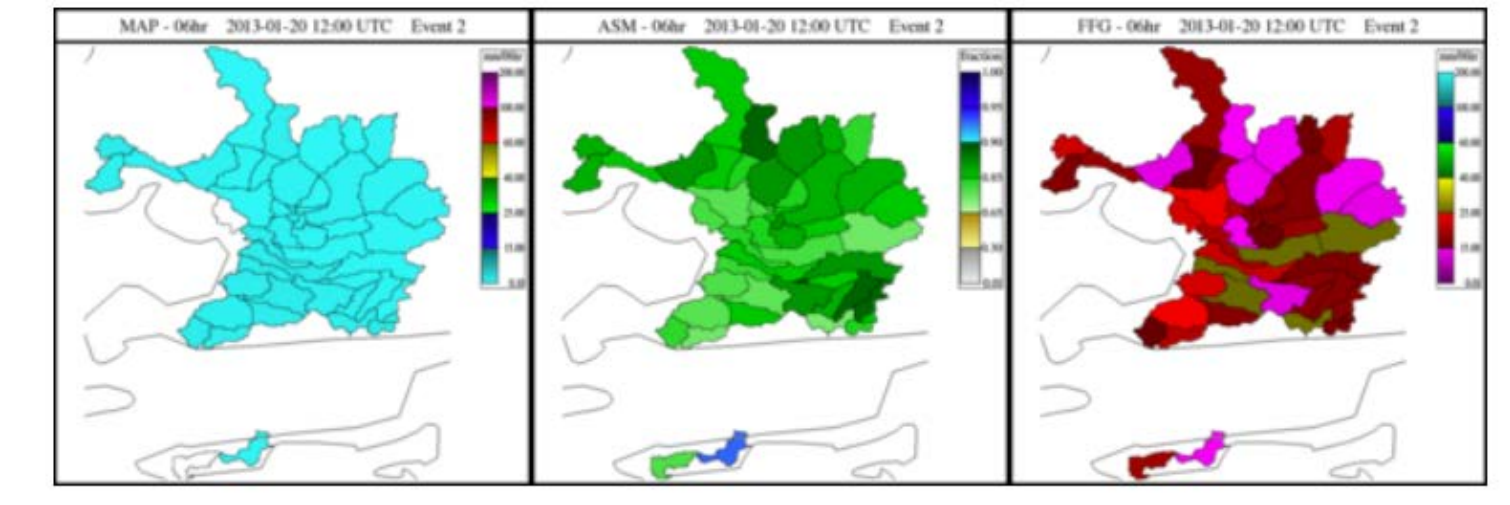

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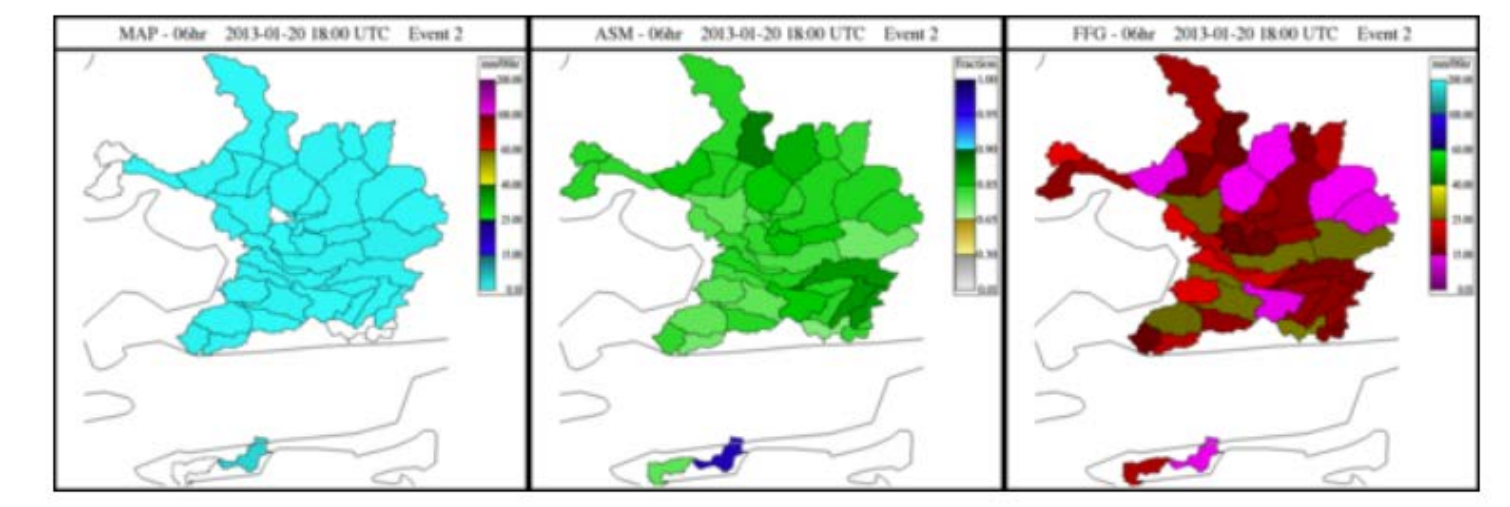

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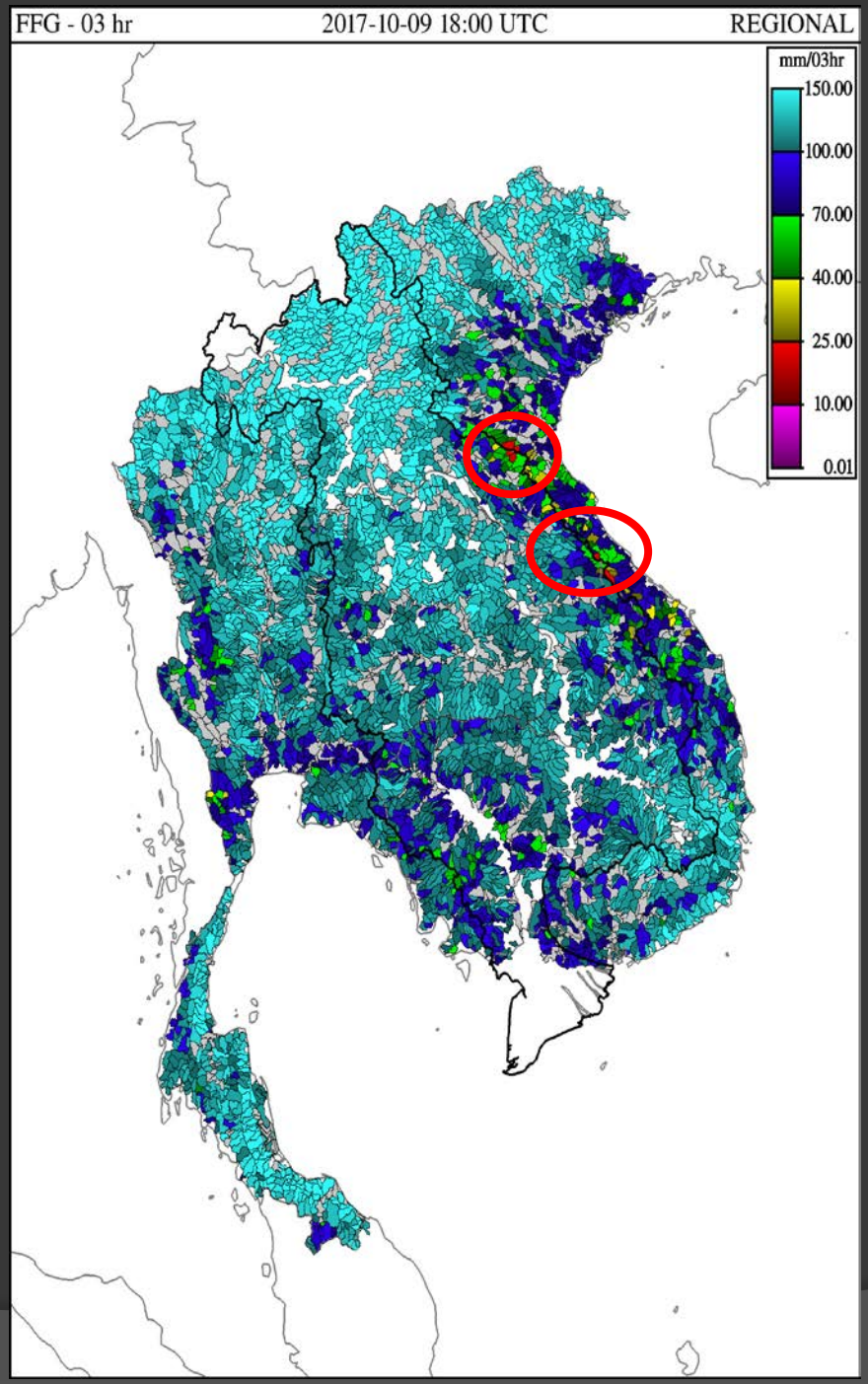


Performance of FFGS so far

FFG provides useful guidance particularly for larger scale systems on potential flash flooding.

- The FFGS systems in the region using satellite rainfall estimation
  - Deal well with larger scale events (TCs, MCSs)
  - Struggle with small scale high intensity events (individual T/S)

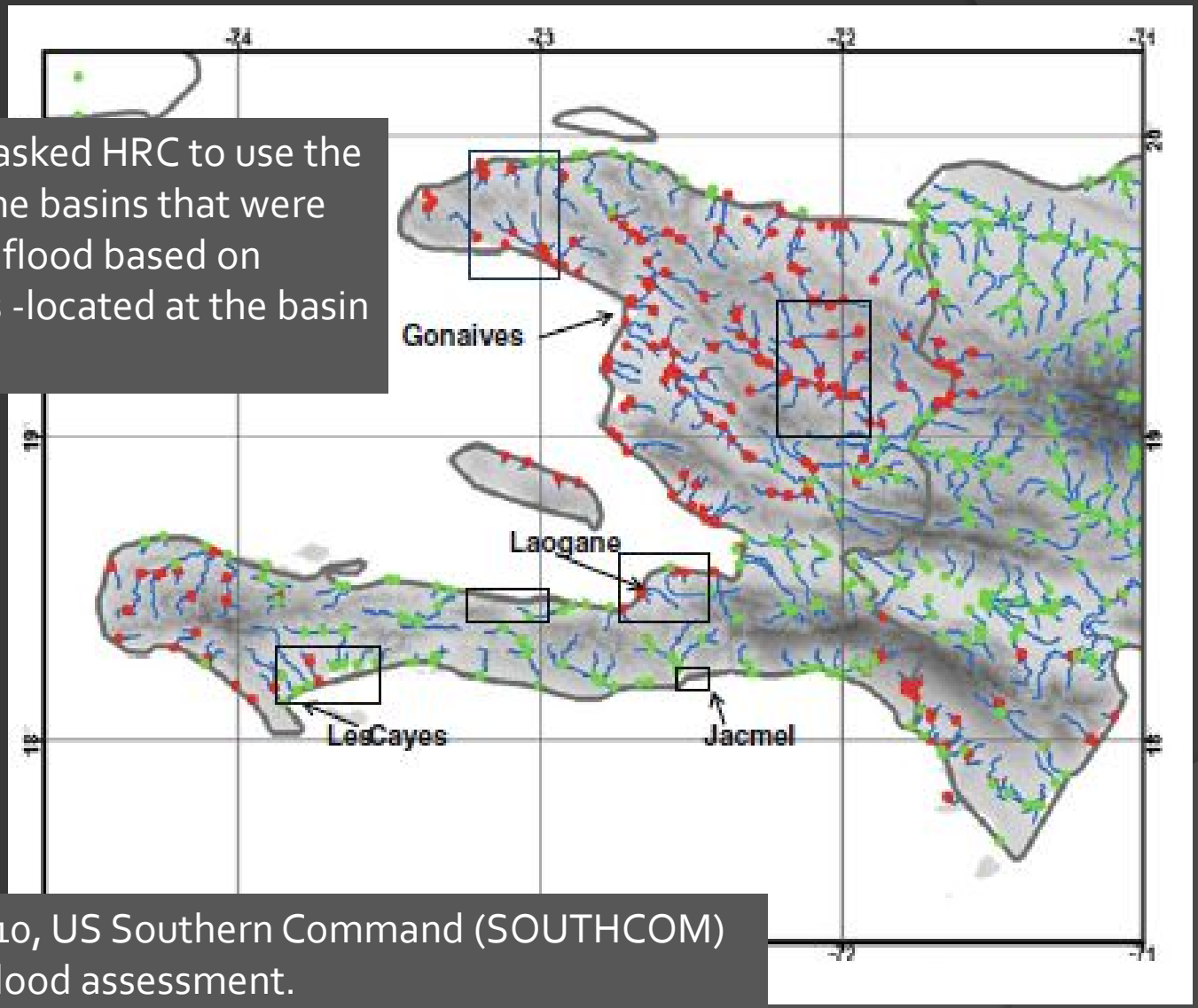
- However, FFG still provide very valuable guidance to forecasters of a hazard that had no information on in the past:

➢ The hydrological response of small streams to rain = greater flash flood potential.

Hurricane Tomas, November 2010

Verification of the FFGS

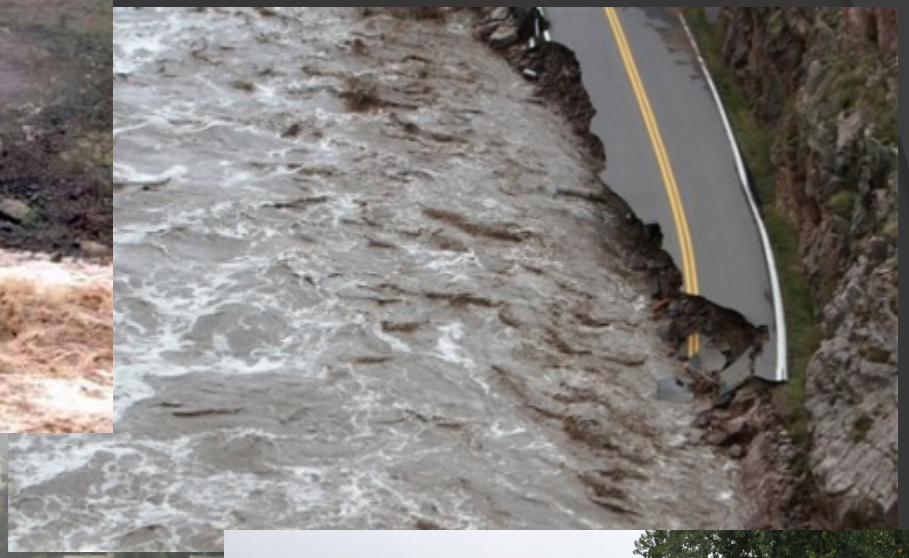
US Southern Command asked HRC to use the FFG system to identify the basins that were likely to generate a flash flood based on satellite rainfall (red dots -located at the basin outlets).



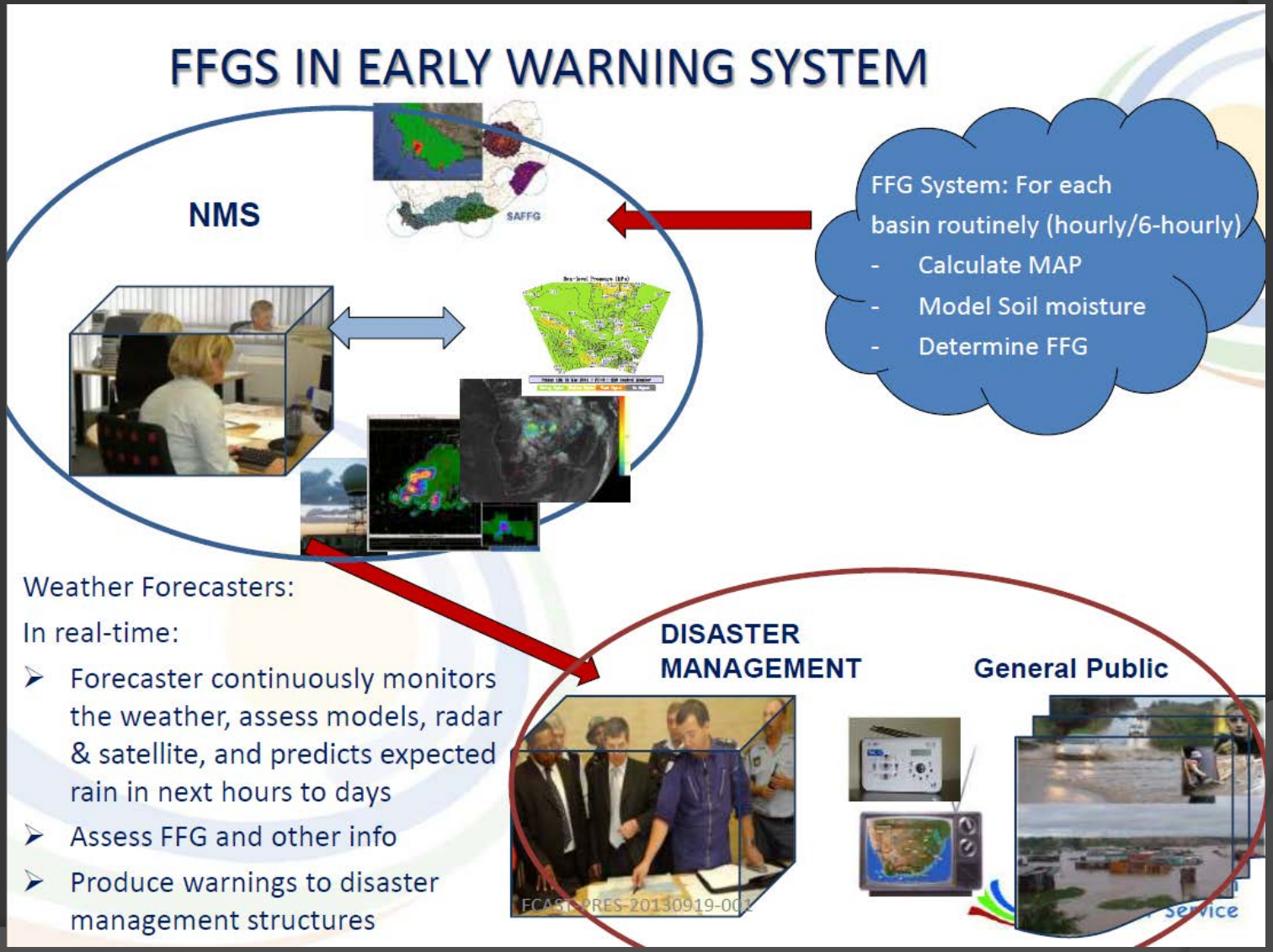
On November 7th, 2010, US Southern Command (SOUTHCOM) conducted an initial flood assessment.

6. Conclusions

Flash flood forecasting is becoming more and more important worldwide

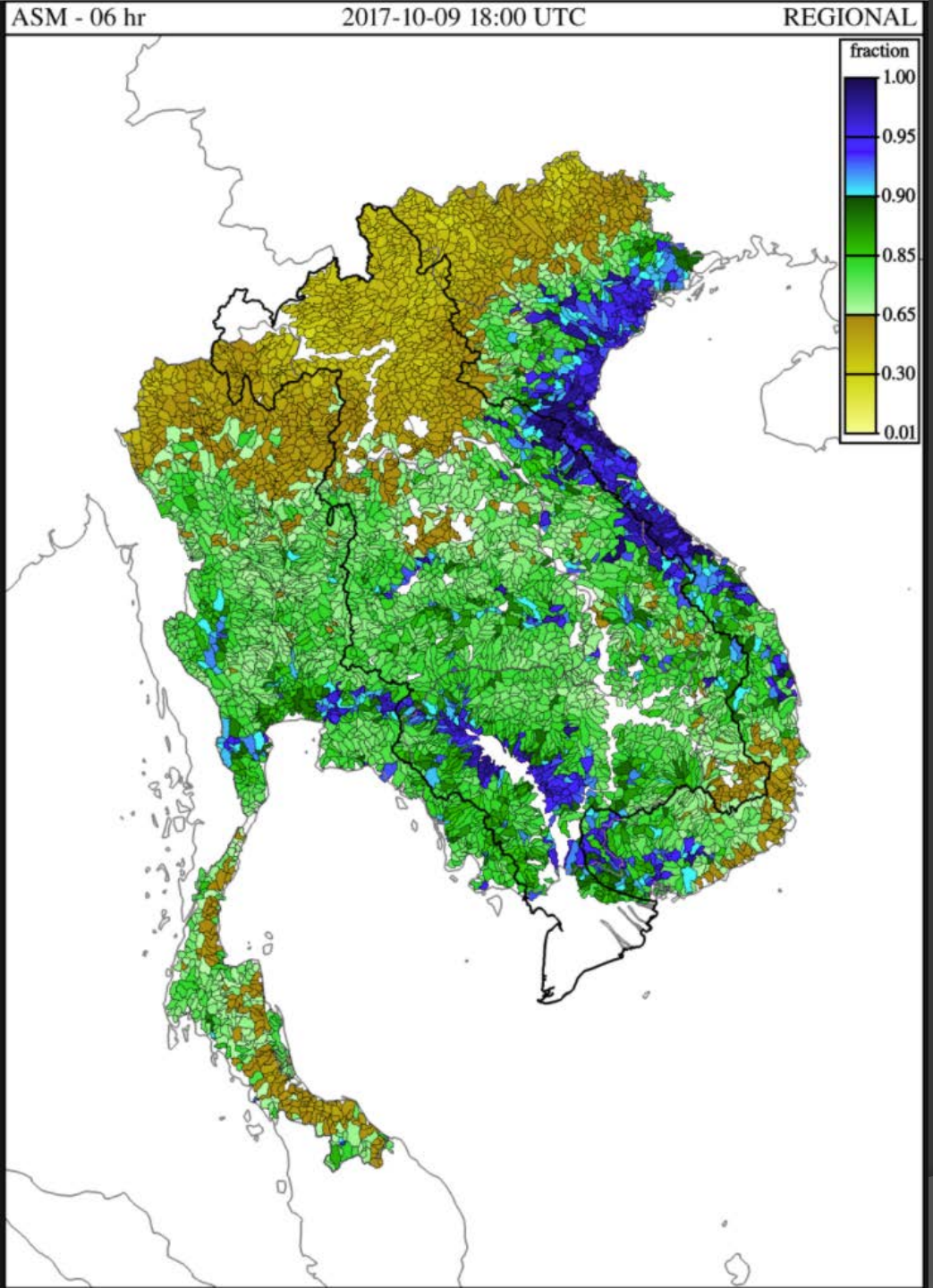


The flash flood guidance system supports forecasters to produce advisories, watches and warnings of the potential for flash floods to disaster management agencies and the public.



Challenges

- Emphasis needs to be on enhancing institutional collaboration
- Stakeholders needs must be understood
- Routine incorporation of the FFG by operational forecasters
- Formalized communication platform of flash flood advisories, watches and warnings with key stakeholders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Thank You