

# **OVERVIEW OF THE FLASH FLOOD GUIDANCE SYSTEM FOR SOUTHEAST ASIA**

**HYDROLOGIC RESEARCH CENTER**

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# 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)

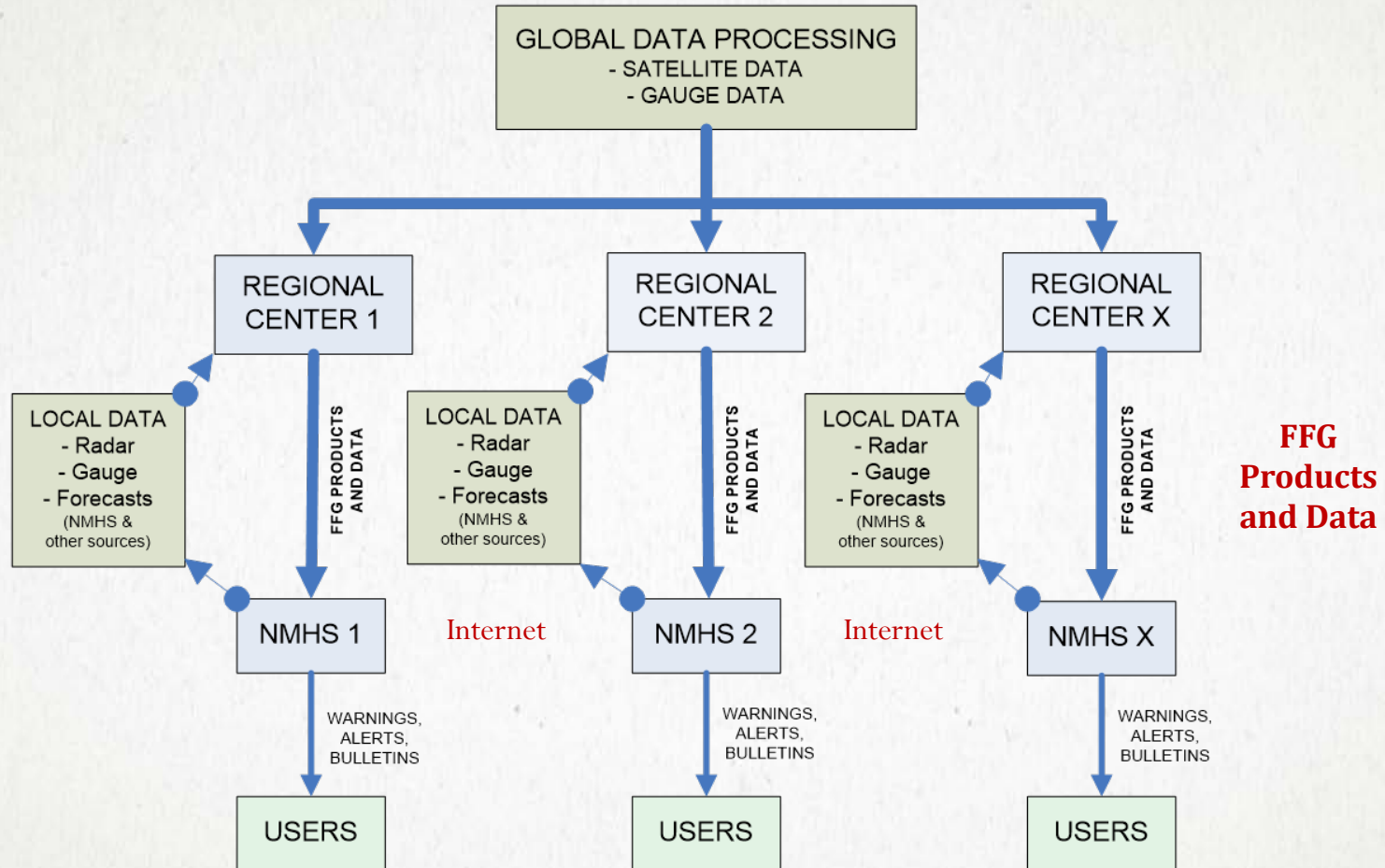
# FLASH FLOOD GUIDANCE SYSTEMS

- The implementation of Flash Flood Guidance (**FFG**) systems is a program to provide a tool for National Meteorological and Hydrologic Services to develop flash flood warnings.
- Addresses the need to provide early warnings for flash floods in the development of **regional or country-wide** approaches to flash flood issues.

## FFG SYSTEM BENEFITS

- Addresses all flash flood prone basins over the area of interest
- Provides information on rainfall and hydrologic response of the basin
- Early awareness of impending local flash flood threats for all potentially vulnerable areas
  - Provide rapid assessments of the **occurrence** (not the magnitude) of a flash flood
  - Only analyzing the occurrence allows for more rapid mobilization, reduces uncertainty and complexity
- **System designed to provide a balance between quality (accuracy) and value (timely)**

# FFG OPERATIONS SCHEMATIC

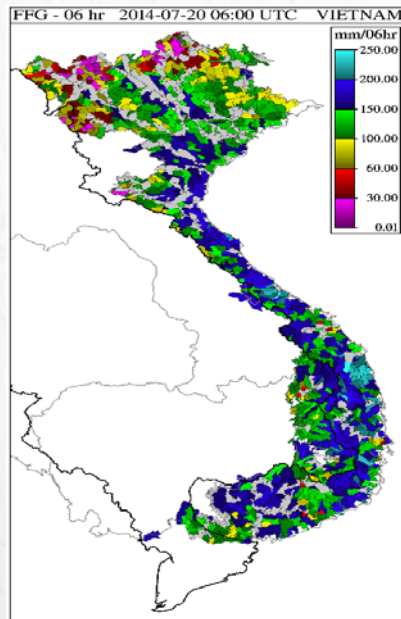




# DEFINITION OF KEY FFG PRODUCTS

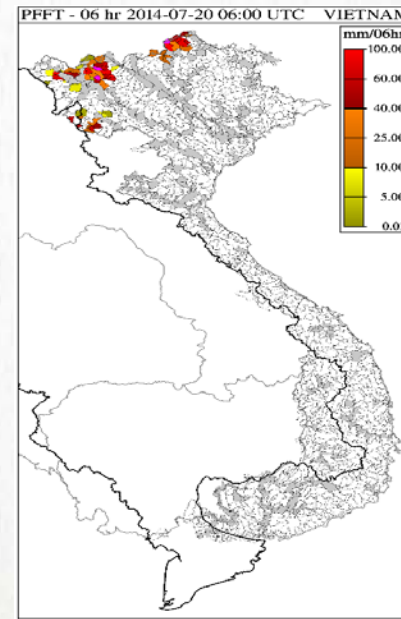
**Flash Flood Guidance** – volume of rainfall of a given duration (1-6 hours) over a given small catchment that is just enough to cause minor flooding at the outlet (bank full flow)

**FFG = INDEX**



**Flash Flood Threat** – rainfall of a given duration in excess of the corresponding Flash Flood Guidance value (**existing/past or “forecast” rainfall**)

**FFT = INDEX**



## BANK FULL FLOW

Bank full flow is a **conservative** measure of flooding as it may not be associated with significant flood damage.

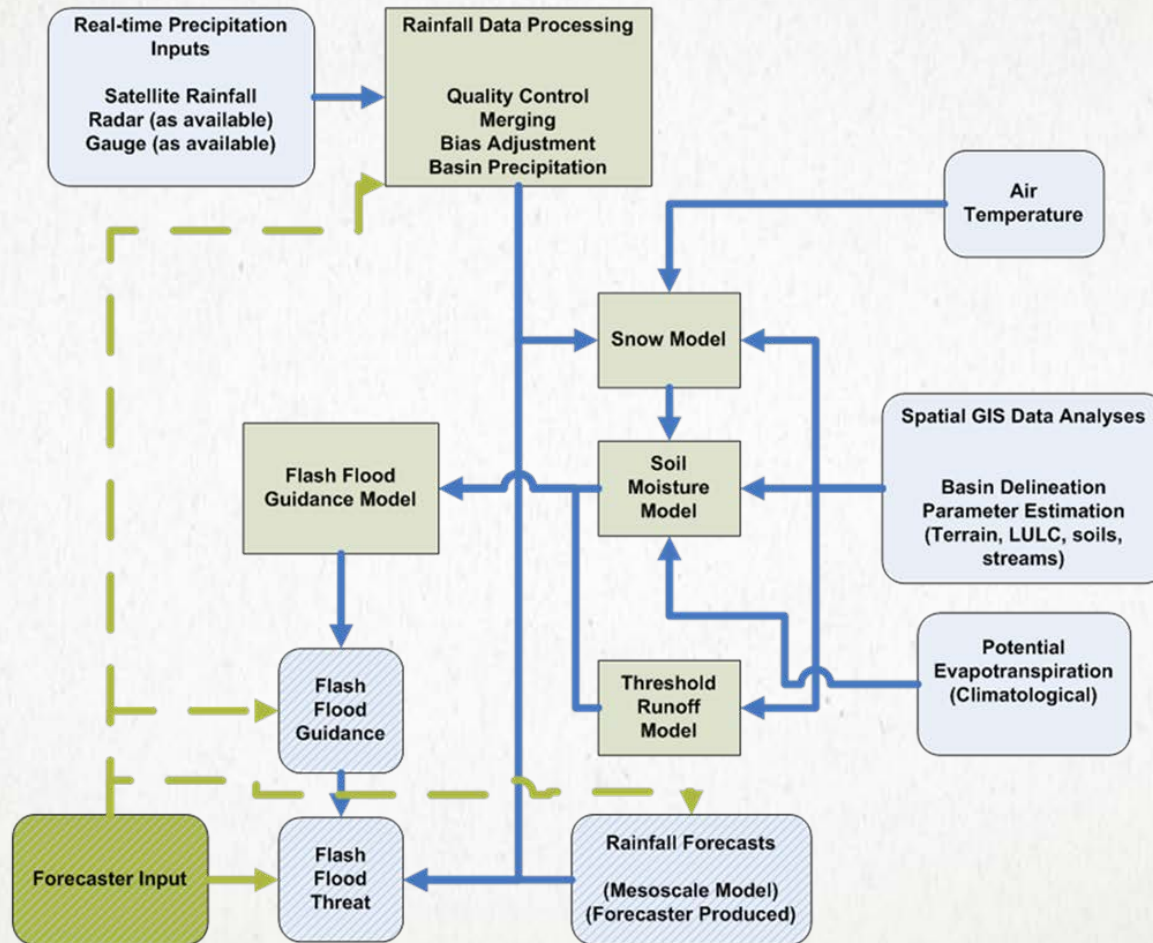


# FLASH FLOOD POTENTIAL

- Potential based on static indicators – basin characteristics
  - Soil type
  - Land cover/land use
  - Slope
  - Stream characteristics – hydraulic depth, bankfull width
- Potential based on dynamic indicators – e.g. soil moisture, rainfall
- FFG system provides access to all these data



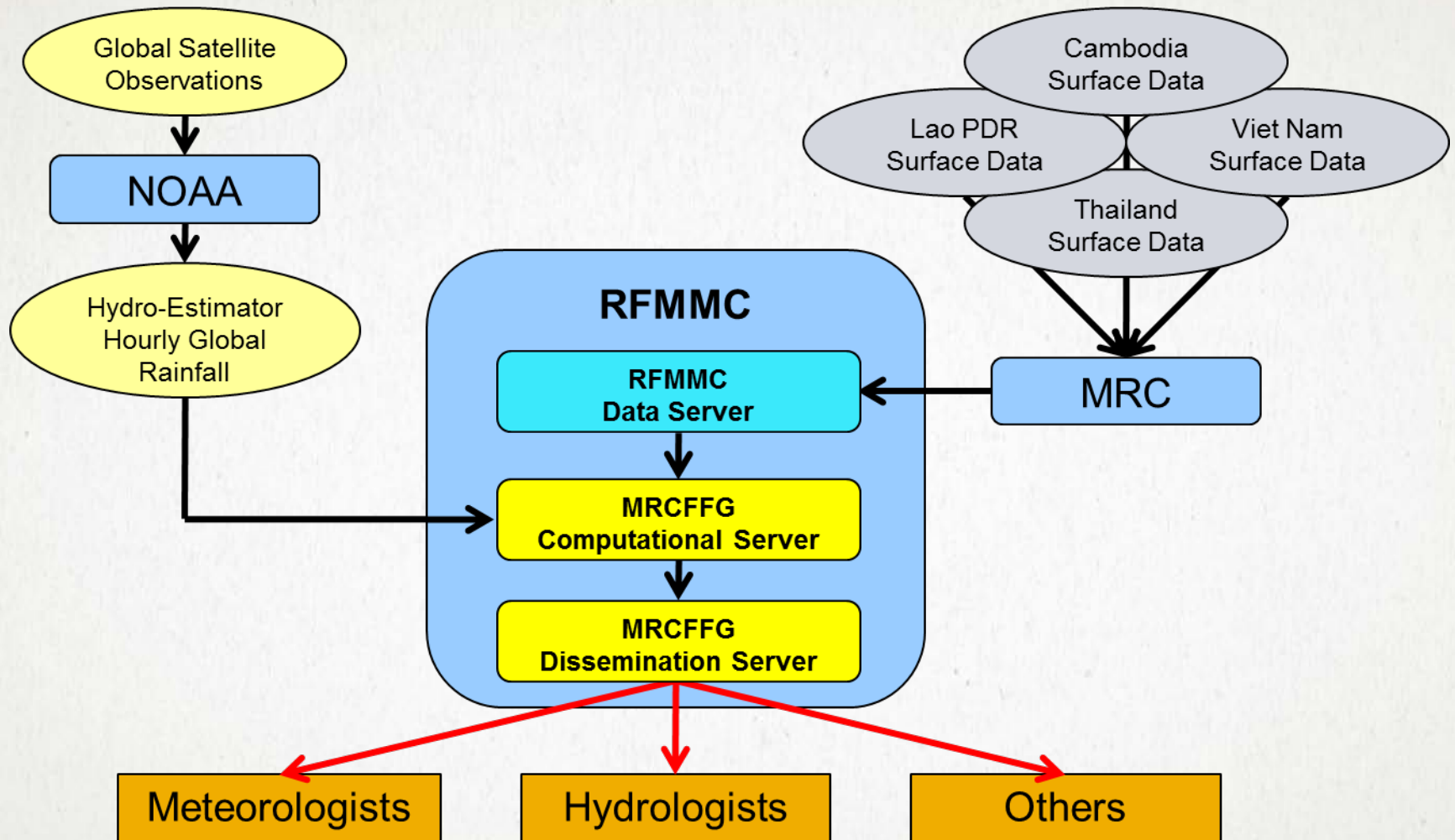
# KEY TECHNICAL COMPONENTS FOR THE STANDARD FFG SYSTEM



## STANDARDIZED FFG SYSTEM

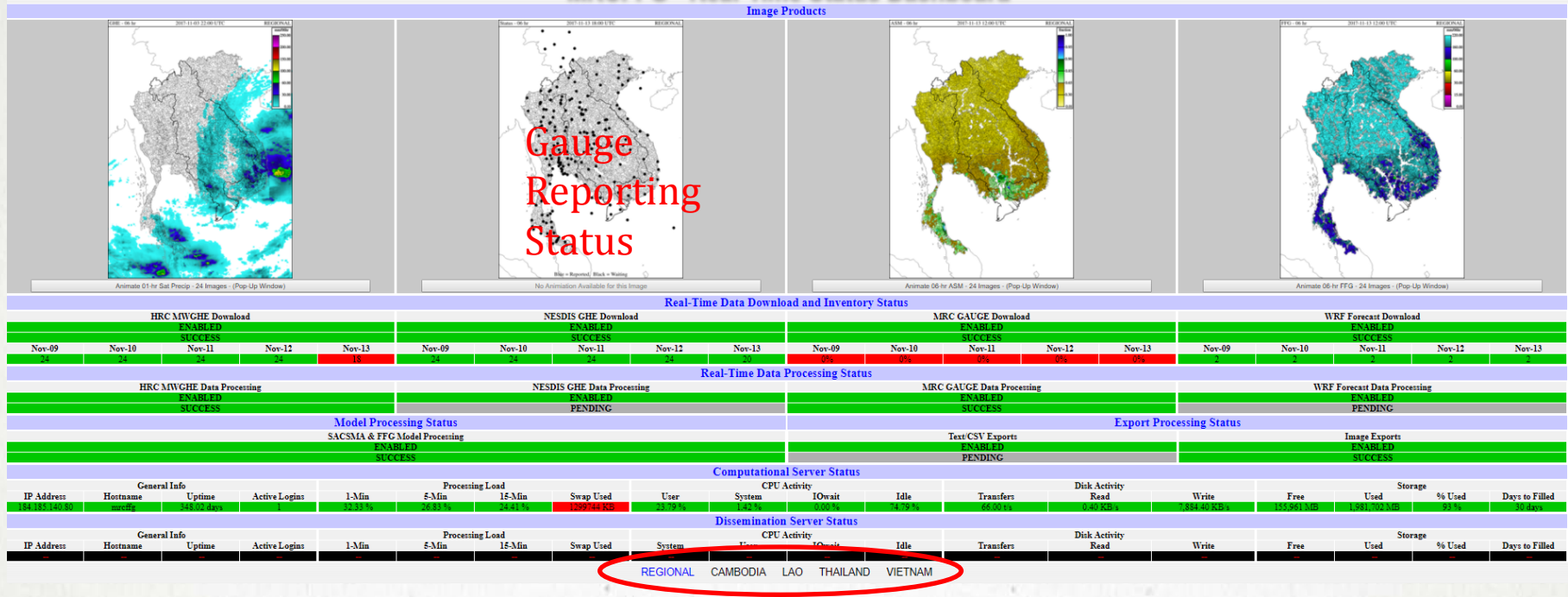
- Real-time Satellite Precipitation Inputs
  - Global HydroEstimator (NOAA/NESDIS) – short latency (<30 minutes), IR-based
  - CMORPH (NOAA/CPC) for Adjustments to the Global HydroEstimator, microwave-based
- Snow Model and Snow Cover
  - SNOW-17 (NOAA/NWS)
- Soil Moisture Model
  - Sacramento Soil Moisture Accounting Model
- Rainfall Forecast Model
  - Mesoscale Models – examples WRF, ALADIN, UNIFIED, HRM

# DATA FLOW SCHEMATIC



# STANDARDIZED FFG SYSTEM DASHBOARD

Can do animations/loops



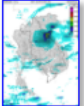
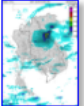
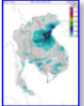
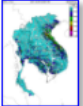
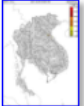
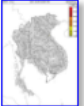
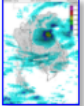
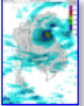
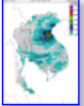
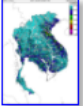
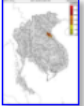
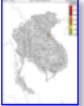
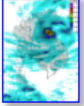
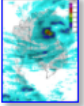
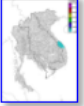
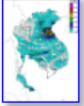

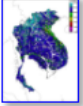
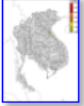
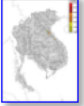
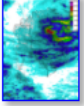
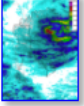
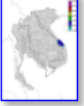
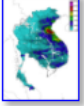
Intended for IT staff and forecasters, to get a quick look at the system status – specifically the real-time data downloads, data processing and server(s) status.



# STANDARDIZED FFG SYSTEM FORECASTER USER INTERFACE

Current Date: 2017-11-13 19:51 UTC      Product Date: 2017-10-09 22:00 UTC  
 Year: 2017    Month: 10    Day: 09    Hour: 22    REGION: REGIONAL    OPTION: MEDIAN    Submit  
 -1 Month   -1 Day   -6 Hours   -1 Hour   +1 Hour   +6 Hours   +1 Day   +1 Month  
 Prev 6-hr Interval (18 UTC)    Reset to Current    Next 6-hr Interval (00 UTC)

## Product Console - Main Table

DT	MWGHE Precipitation	GHE Precipitation	Gauge MAP	Merged MAP	ASM	FFG	IFFT	PFFT
01-hr	 2017-10-09 22:00 UTC Text: <a href="#">view</a>	 2017-10-09 22:00 UTC Text: <a href="#">view</a>		 2017-10-09 22:00 UTC Text: <a href="#">view</a>		 2017-10-09 18:00 UTC Text: <a href="#">view</a>	 2017-10-09 19:00 UTC Text: <a href="#">view</a>	 2017-10-09 18:00 UTC Text: <a href="#">view</a>
03-hr	 2017-10-09 22:00 UTC Text: <a href="#">view</a>	 2017-10-09 22:00 UTC Text: <a href="#">view</a>		 2017-10-09 22:00 UTC Text: <a href="#">view</a>		 2017-10-09 18:00 UTC Text: <a href="#">view</a>	 2017-10-09 21:00 UTC Text: <a href="#">view</a>	 2017-10-09 18:00 UTC Text: <a href="#">view</a>
06-hr	 2017-10-09 22:00 UTC Text: <a href="#">view</a>	 2017-10-09 22:00 UTC Text: <a href="#">view</a>	 2017-10-09 18:00 UTC Text: <a href="#">view</a>	 2017-10-09 22:00 UTC Text: <a href="#">view</a>	 2017-10-09 18:00 UTC Text: <a href="#">view</a>	 2017-10-09 18:00 UTC Text: <a href="#">view</a>	 2017-10-09 18:00 UTC Text: <a href="#">view</a>	 2017-10-09 18:00 UTC Text: <a href="#">view</a>
24-hr	 2017-10-09 22:00 UTC Text: <a href="#">view</a>	 2017-10-09 22:00 UTC Text: <a href="#">view</a>	 2017-10-09 18:00 UTC Text: <a href="#">view</a>	 2017-10-09 22:00 UTC Text: <a href="#">view</a>				

Composite Product: [text](#) , [CSV](#) , [CSVT](#)

SFTP data transfer (requires SFTP Client): [EXPORTS/REGIONAL/2017/10/09](#)

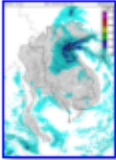
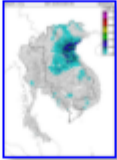
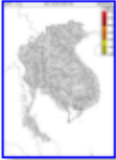
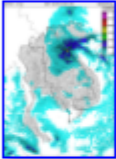
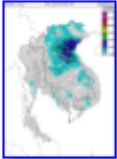
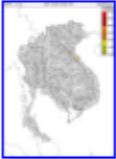
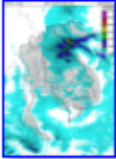
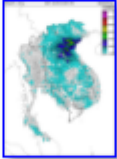

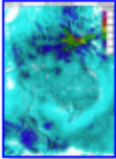
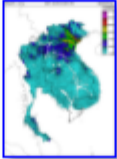
### Surfmet Gauge Observations at 2017-10-09 22:00 UTC

Station Identifier	Station Name	Accumulated Precipitation (mm/01hr)	Average Temperature (C)	Region	Latitude	Longitude	Elevation	Enable Precipitation Flag
No reports for region	No reports for region	No reports for region	No reports for region	No reports for region	No reports for region	No reports for region	No reports for region	No reports for region

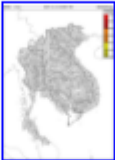
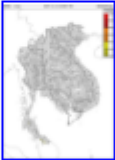
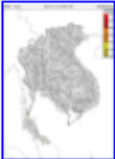
Thumbnails to access a Map Server Interface

# STANDARDIZED FFG SYSTEM FORECASTER USER INTERFACE

## Product Console - Model Forecast Products

DT	WRF Forecast	FMAP	FFFT
01-hr	 2017-10-09 22:00 UTC <a href="#">Text: view</a>	 2017-10-09 22:00 UTC <a href="#">Text: view</a>	 2017-10-09 18:00 UTC <a href="#">Text: view</a>
03-hr	 2017-10-09 22:00 UTC <a href="#">Text: view</a>	 2017-10-09 22:00 UTC <a href="#">Text: view</a>	 2017-10-09 18:00 UTC <a href="#">Text: view</a>
06-hr	 2017-10-09 22:00 UTC <a href="#">Text: view</a>	 2017-10-09 22:00 UTC <a href="#">Text: view</a>	 2017-10-09 18:00 UTC <a href="#">Text: view</a>
24-hr	 2017-10-09 22:00 UTC <a href="#">Text: view</a>	 2017-10-09 22:00 UTC <a href="#">Text: view</a>	

## Product Console Baseline Threat Products

DT	Flash Flood Risk
12-hr	 2017-11-13 18:00 UTC <a href="#">Text: view</a>
24-hr	 2017-11-13 18:00 UTC <a href="#">Text: view</a>
36-hr	 2017-11-13 18:00 UTC <a href="#">Text: view</a>

# BASIN DELINEATIONS

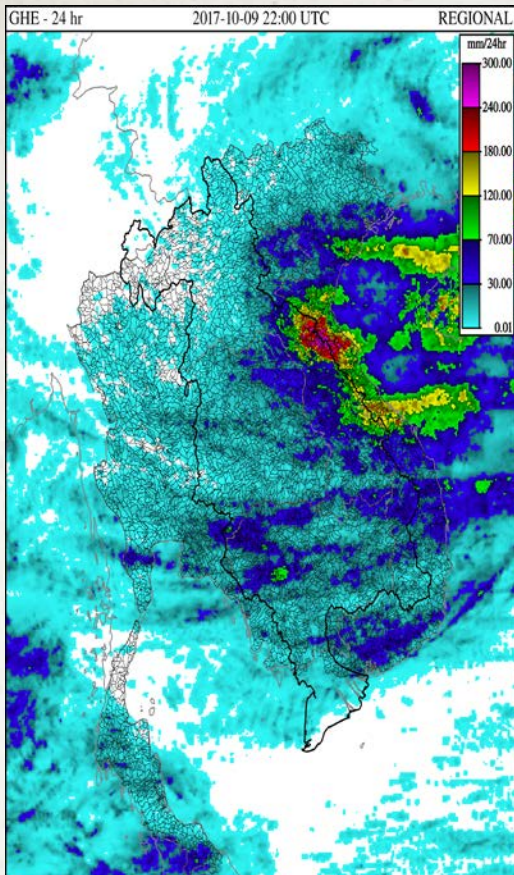


6372 sub-basins

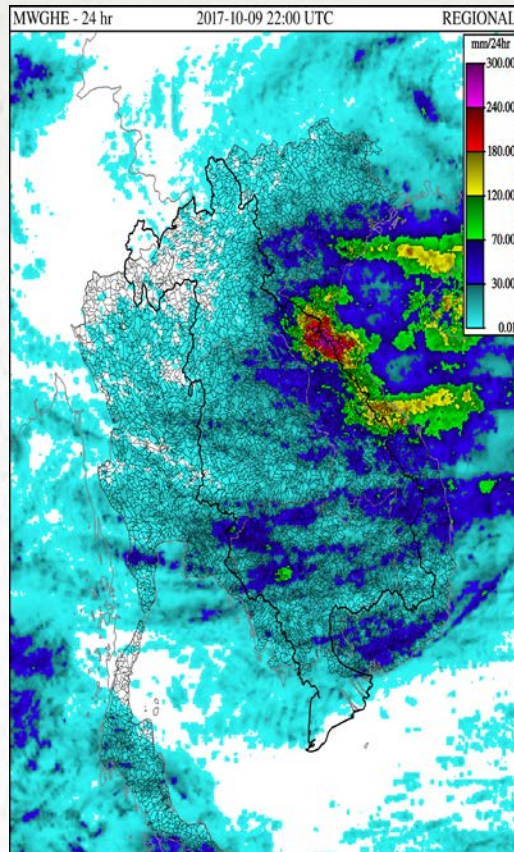
Mean area  $\sim 180 \text{ km}^2$

For Radars  $\sim 30\text{-}70 \text{ km}^2$

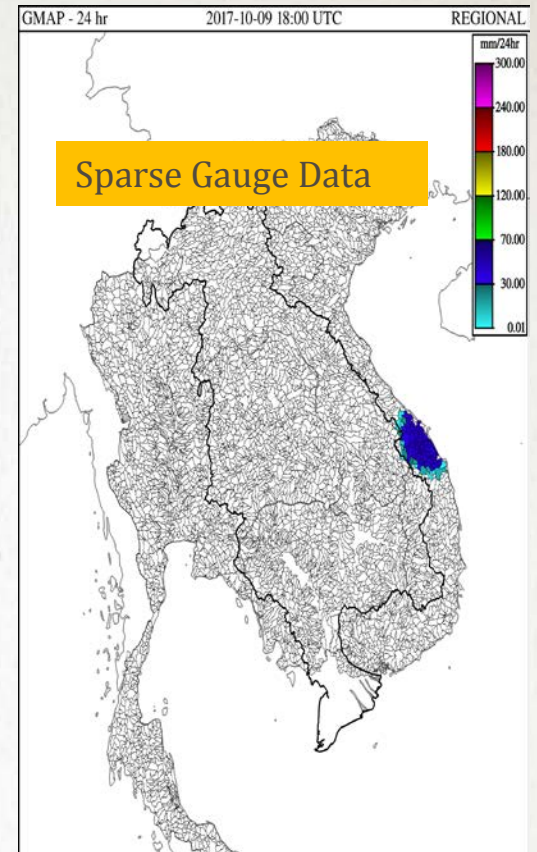




Precipitation estimates from the Global HydroEstimator, NOAA

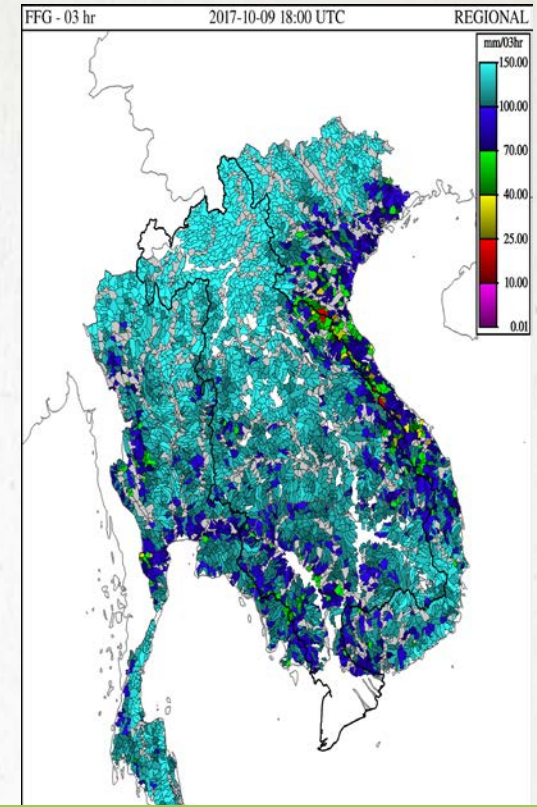
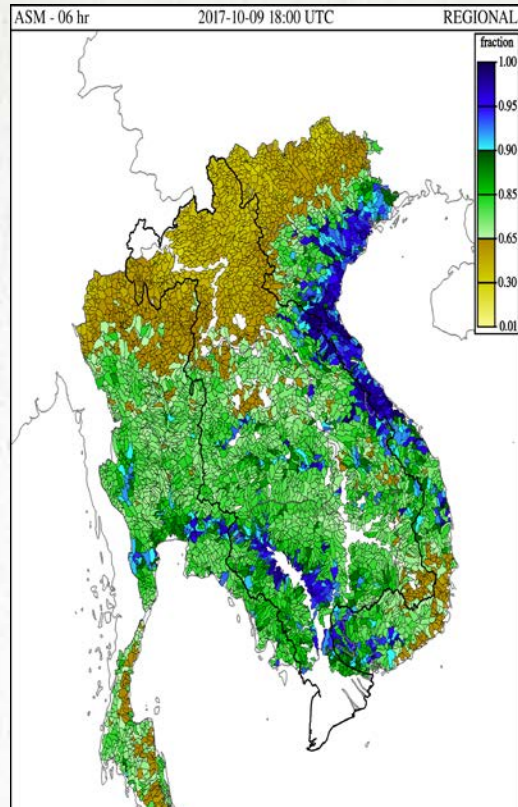
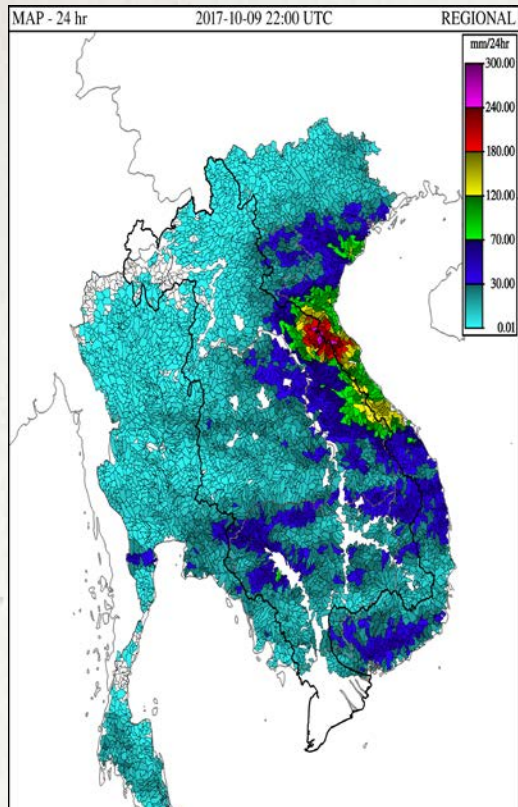


Precipitation estimates from the CMORPH (micro-wave) adjusted Global HydroEstimator, NOAA



Mean areal precipitation for each flash flood basin based on gauges



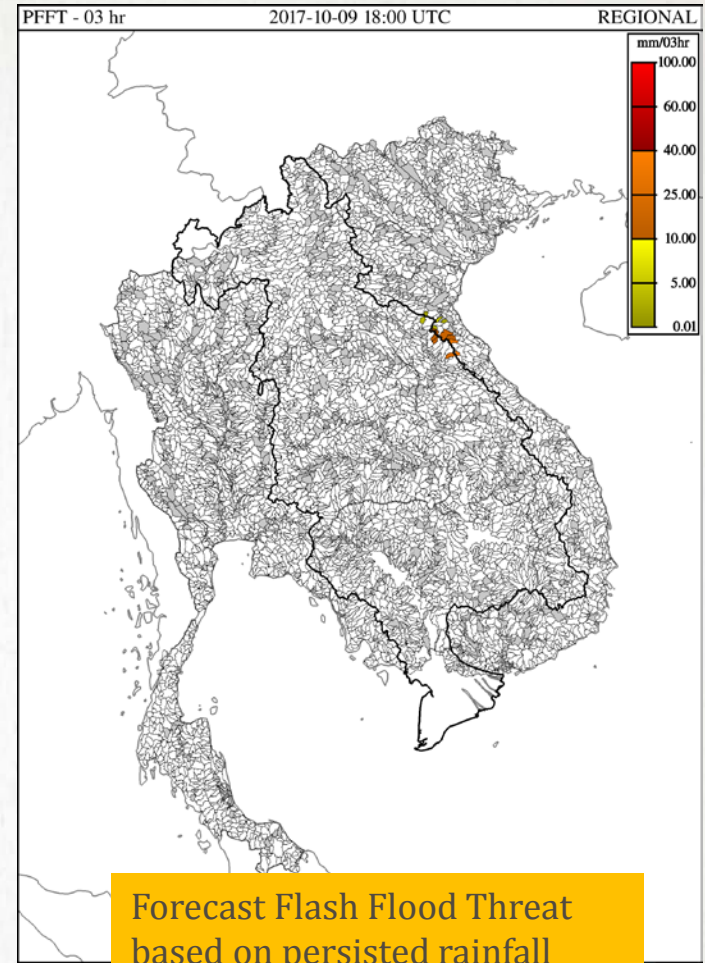
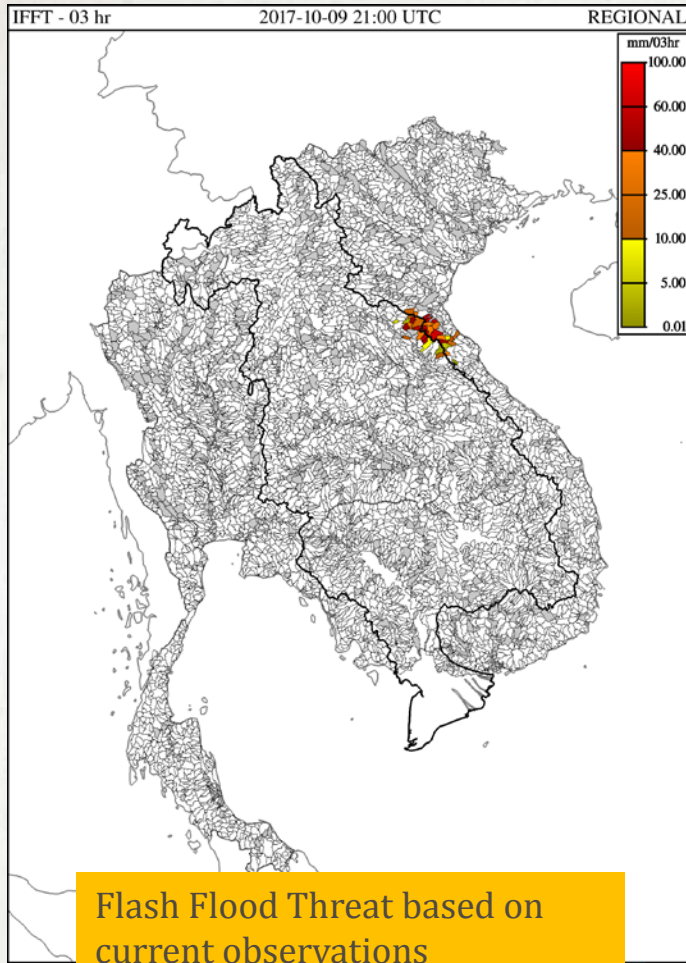


Mean areal precipitation for each flash flood basin based on bias-corrected satellite, radar, or gauge estimates

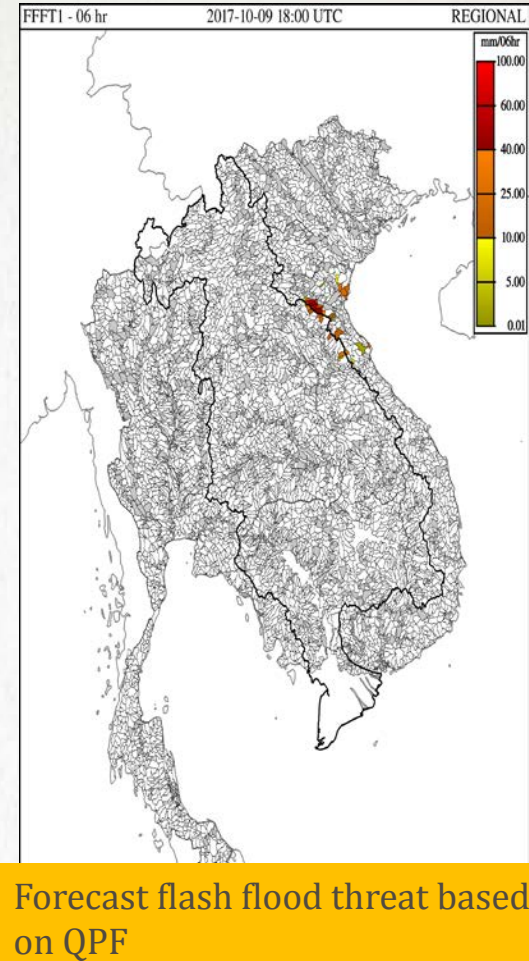
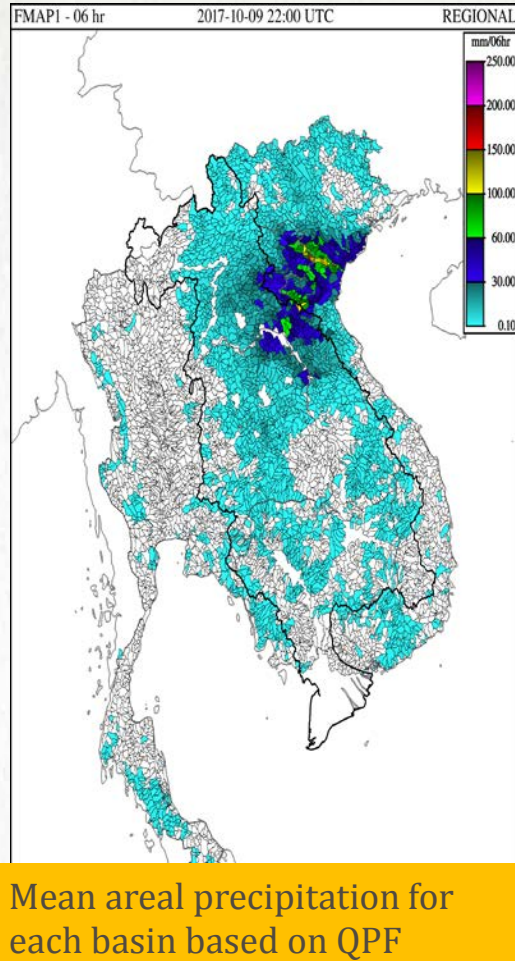
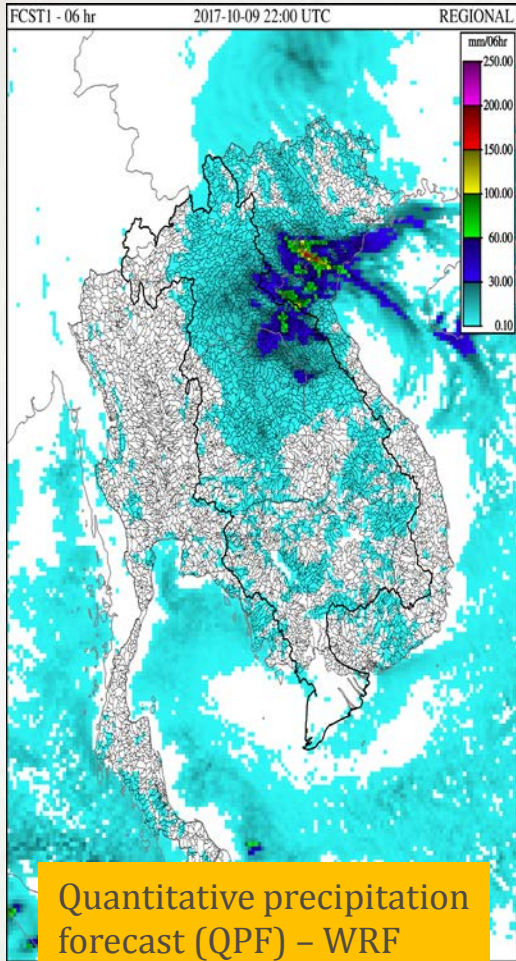
Model-based soil moisture for each basin presented as fraction of saturation (top 20 cm)

Flash Flood Guidance values for each basin. The lower the FFG, the more likely flooding will occur during a rainfall event

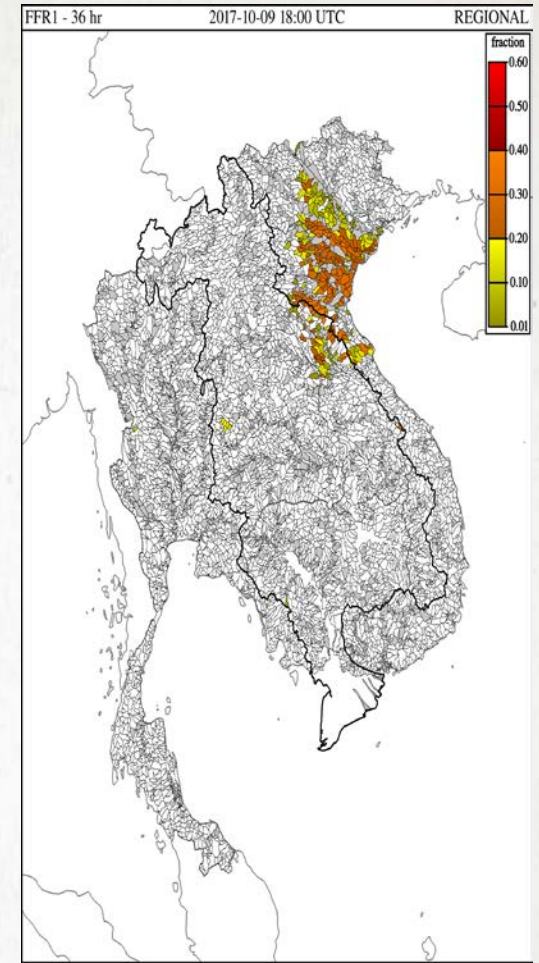
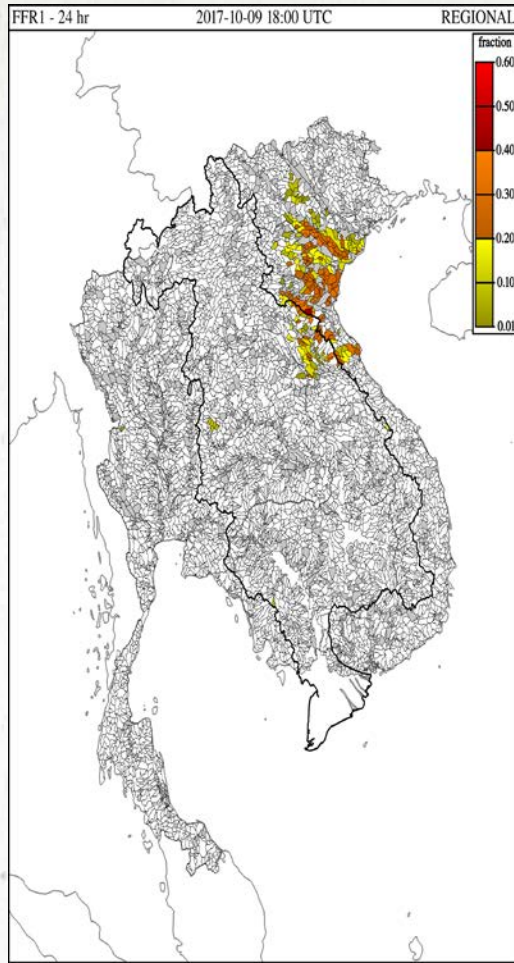
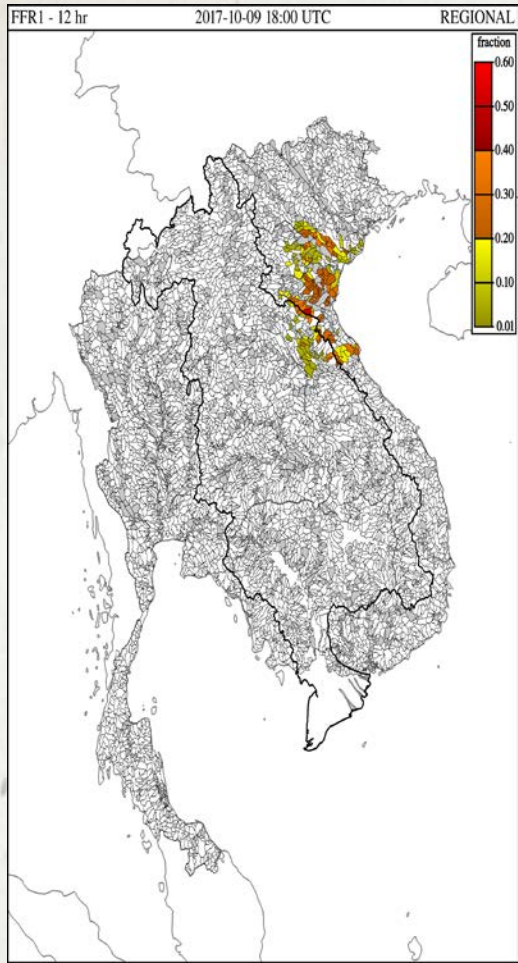
## Radars







## Model Information



## 12, 24, and 36-hour Flash Flood Risk





# PRODUCT DESCRIPTIONS AVAILABLE

## MRCFFG Real-Time Product Console Operational Output Product Descriptions

The MRCFFG Real-Time Product Console system provides a collection of real-time data products in text, image and CSV file formats. The text products are available for direct review as well as download using the web interface. Each hour, the system provides images and text tables related to estimated and forecast precipitation products. All other products are updated every six hours. Even though the system's primary product is the FFG data, the other products are made available so that the forecaster can leverage that information in their efforts for quality control and in their assessments when further applying the FFG data in their operational forecasting activities.

The following identifies and describes each of the MRCFFG Real-Time Product Console system operational output products (from left to right on the above figure). In interpreting the following products, the term "navigation hour" refers to every hour at the top of the hour (e.g., 00Z, 01Z, 02Z etc.) while the term "model processing hour" refers to the six-hour updates of the soil moisture model matching the rainfall gauge accumulation reports (e.g., 00Z, 06Z, 12Z, 18Z).

Label	Definition	Format	Updated	Description
MWGHE	Microwave-adjusted Global HydroEstimator Satellite-based Precipitation Estimates	Text & Images	Hourly	<p>The images and text provide gridded 1-hour, 3-hour, 6-hour and 24-hour accumulations of satellite-based rainfall estimates (mm) ending on the current hour from the NOAA-NESDIS Global HydroEstimator (infrared-based) and adjusted by the NOAA-CPC CMORPH microwave-based satellite rainfall product. The satellite-based rainfall estimates are provided on a grid which is displayed over a background of the system sub-basin boundaries. The MWGHE data products are updated every hour with a latency of approximately 45 minutes and are <u>not</u> bias-corrected (see Merged MAP product). <b>This product is provided for visual quality control assessment of the adjusted satellite input.</b></p> <p><b>MWGHE 01-hr:</b> Accumulations of rainfall estimates from the microwave-adjusted Global HydroEstimator over the last hour ending on the current navigation hour. (mm/1hr)  <b>MWGHE 03-hr:</b> Accumulations of rainfall estimates from the microwave-adjusted Global HydroEstimator over the last 3 hours ending on the current navigation hour. (mm/3hr)  <b>MWGHE 06-hr:</b> Accumulations of rainfall estimates from the microwave-adjusted Global HydroEstimator over the last 6 hours ending on the current navigation hour. (mm/6hr)  <b>MWGHE 24-hr:</b> Accumulations of rainfall estimates from the microwave-adjusted Global HydroEstimator over the last 24 hours ending on the current navigation hour. (mm/24hr)</p> <p><b>Missing 01-hr MWGHE:</b> In the event that the 01-hr MWGHE input product is unavailable or missing, the sub-basin boundaries are displayed in red.</p> <p><b>Accumulated MWGHE Products:</b> Each of the 3-, 6- and 24-hour MWGHE accumulations are produced from the 01-hr MWGHE rainfall input products summed over the corresponding interval, ending on the navigation hour. <b>Each of these accumulations requires the availability of at least 50% of the 1-hr MWGHE products over the corresponding interval.</b> If more than 50% of the 1-hr products are missing or unavailable over any accumulation interval, a <b>gray</b> image is shown to indicate insufficient 01-hr satellite input data were available.</p>
GHE	Global HydroEstimator Satellite-based Precipitation Estimates	Text & Images	Hourly	<p>The images and text provide gridded 1-hour, 3-hour, 6-hour and 24-hour accumulations of satellite-based rainfall estimates (mm) ending on the current hour from the NOAA-NESDIS HydroEstimator. The satellite-based rainfall estimates are provided on a grid which is displayed over a background of system sub-basin boundaries. The data products are updated every hour with a latency of approximately 25 minutes and are <u>not</u> bias-corrected (see Merged MAP product). <b>This product is provided for visual quality control assessment of the satellite input.</b></p> <p><b>GHE 01-hr:</b> Accumulations of rainfall estimates from the Global HydroEstimator over the last hour ending on the current navigation hour. (mm/1hr)  <b>GHE 03-hr:</b> Accumulations of rainfall estimates from the Global HydroEstimator over the last 3 hours ending on the current navigation hour. (mm/3hr)  <b>GHE 06-hr:</b> Accumulations of rainfall estimates from the Global HydroEstimator over the last 6 hours ending on the current navigation hour. (mm/6hr)  <b>GHE 24-hr:</b> Accumulations of rainfall estimates from the Global HydroEstimator over the last 24 hours ending on the current navigation hour. (mm/24hr)</p> <p><b>Missing 01-hr GHE:</b> In the event that the 01-hr GHE input product is unavailable or missing, the sub-basin boundaries are displayed in red. GHE data availability can be monitored using the system Dashboard.</p> <p><b>Accumulated GHE Products:</b> Each of the 3-, 6- and 24-hour GHE accumulations are produced from the 01-hr GHE rainfall input products summed over the corresponding interval, ending on the navigation hour. <b>Each of these accumulations requires the availability of at least 50% of the 1-hr GHE observations over the corresponding interval.</b> If more than 50% of the 1-hr GHE observations are missing or unavailable over any accumulation interval, a <b>gray</b> image is shown to indicate insufficient 01-hr satellite input data were available.</p>
Gauge MAP	Gauge Mean Areal Precipitation	Text & Images	00, 06, 12, and 18 UTC	<p>The images and text provide 6-hour and 24-hour accumulations of mean areal precipitation (mm) estimates for each sub-basin produced from interpolation of precipitation gauge data. The Gauge MAP data products are updated every six hours and reflect accumulations of basin-average precipitation of a given duration ending on the current navigation hour.</p> <p><b>GMAP 06-hr:</b> Accumulations of gauge-interpolated mean areal precipitation estimates over the last 6 hours ending on the current navigation hour. (mm/6hr)  <b>GMAP 24-hr:</b> Accumulations of gauge-interpolated mean areal precipitation estimates over the last 24 hours ending on the current navigation hour. (mm/24hr)</p> <p><b>Gauge Interpolation and GMAP:</b> The interpolation of the gauge precipitation is performed on the observations made by a predefined list of "Active" stations. Only observations from these stations are incorporated into the gauge precipitation interpolation. Zero precipitation is assigned to active stations that did not report an observation. The Gauge MAP product is then derived for all sub-basins from the interpolated 6-hourly station observations.</p> <p><b>Gauge data availability can be monitored using the system Dashboard.</b></p>



# STATIC RESOURCES AVAILABLE

Static Resources and Reference Materials

Category	Item	Resource Link	Description
GIS Data Layers	MRCFFG Sub-Basin Shapefiles All Layers (21M)	<a href="#">MRCFFG All Shapefiles</a>	A zipped archive (*.zip) of the component files for all shapefile layers from boundaries for all MRCFFG export regions. This is a single download file that includes "all" of the individual archives offered below.
GIS Data Layers	REGIONAL Sub-Basin Shapefiles (11M)	<a href="#">MRCFFG REGIONAL Shapefile</a>	A zipped archive (*.zip) of the shapefile component files that provide basins boundaries for the REGIONAL export region.
GIS Data Layers	CAMBODIA Sub-Basin Shapefiles (1.3M)	<a href="#">MRCFFG CAMBODIA Shapefile</a>	A zipped archive (*.zip) of the shapefile component files that provide basins boundaries for the CAMBODIA export region.
GIS Data Layers	LAO Sub-Basin Shapefiles (1.6M)	<a href="#">MRCFFG LAO Shapefile</a>	A zipped archive (*.zip) of the shapefile component files that provide basins boundaries for the LAO export region.
GIS Data Layers	MYANMAR Sub-Basin Shapefiles (3.3M)	<a href="#">MRCFFG MYANMAR Shapefile</a>	A zipped archive (*.zip) of the shapefile component files that provide basins boundaries for the MYANMAR export region.
GIS Data Layers	THAILAND Sub-Basin Shapefiles (2.2M)	<a href="#">MRCFFG THAILAND Shapefile</a>	A zipped archive (*.zip) of the shapefile component files that provide basins boundaries for the THAILAND export region.
GIS Data Layers	VIETNAM Sub-Basin Shapefiles (2.2M)	<a href="#">MRCFFG VIETNAM Shapefile</a>	A zipped archive (*.zip) of the shapefile component files that provide basins boundaries for the VIETNAM export region.
Software Download	Quantum GIS (129MB)	<a href="#">QGIS v.1.8.0-2</a>	A free, GUI-based GIS software package available for Windows (available for Linux platforms too). This package may be used to visualize FFGS reference shapefiles and to merge FFGS CSV composite product files to those shapefiles for interactive forecaster review and modification. QGIS may also be used for visual overlay of additional GIS resources, if available, such as stations, roads, cities, populations, provincial boundaries, etc. For more information about this software, visit the QGIS <a href="#">web site</a> .
Software Download	7-Zip v9.22 Archive Utility (1MB)	<a href="#">7-Zip Installer for Windows</a>	A free, popular and light-weight GUI-based data archive creation/extraction utility for Windows. (This software is provided as a solution to unpack the FFGS GIS shapefile archives provided above.) For more information about this software, visit the 7-Zip <a href="#">web site</a> .
Software Download	WinSCP v5.1.4 SCP Client (5MB)	<a href="#">WinSCP Installer for Windows</a>	A free, popular and light-weight SCP client for Windows allowing GUI navigation as well as drag-and-drop transfers. (This software might be required for web-browser-activated access to SFTP downloads from the FFGS export archives linked within the FFGS Product Console interface.) For more information about this software, visit the WinSCP <a href="#">web site</a> .

Software Download	PuTTY SSH v0.62 SSH Client (1.7MB)	<a href="#">PuTTY Installer for Windows</a>	A free, popular and light-weight SSH client for Windows providing secure, remote logins. (Optional. Not required for use of the FFGS or its data products, but may be used for direct shell login to the FFGS Dissemination Server in order to setup SSH keys for automated authentication during advanced FFGS text/image product download procedures.) For more information about this software, visit the PuTTY <a href="#">web site</a> .
Software Information	Cygwin	<a href="#">Cygwin (Home Page)</a>	A free, Linux-like software layer that runs on top of Windows providing a full-featured Linux environment including terminal shells, GNU compilers, SSH, SCP, cron and X-Windows. (Optional. Not required for use of the FFGS or its data products, but might be useful to establish, manage and post-process automated downloads of FFGS text/image products to a Windows PC using Linux tools and methodologies. Recommended only for advanced users already familiar with basic Linux administration and shell scripting.)
Demonstration (Download)	Shockwave Flash Video (4MB)	<a href="#">FFGS ArcView Demonstration Video</a>	A training video (standalone executable Shockwave file) that demonstrates the use of ArcView as a GIS to manipulate FFGS data products obtained from the FFGS Dissemination Server. To watch, just double-click the executable file after download.
Demonstration (Streaming)	Shockwave Flash Video	<a href="#">FFGS ArcView Demonstration Video</a>	A training video (streaming flash video in browser) that demonstrates the use of ArcView as a GIS to manipulate FFGS data products obtained from the FFGS Dissemination Server. The video will open in a new window after clicking on the link.
Documentation	MRCFFG User's Guide (coming)	MRCFFG User's Guide	Forecaster- and SysAdmin-Centric discussion related to the MRCFFG system installation, design, usage, maintenance and sustainability.

## SUSTAINABILITY

- Proven concept in many regional and country applications
- Robust operation and stability of the FFG system software
- Adaptable to various regional and local conditions (environment, institutional, technical)
- Dedicated capacity-building component



## POTENTIAL FUTURE ENHANCEMENTS

- Multi-NWP QPF Ingestion
- Implement a rainfall-induced landslide hazard threat product
  - Using soil moisture and rainfall thresholds from FFG systems
- Evaluate urban flooding issues
- Riverine Routing
- Seasonal and sub-seasonal discharge prediction



Landslide Susceptibility Map



THANK YOU

## MESOSCALE MODEL INGESTION

- Up to five (5) different models can be run through the FFG
- Allows forecaster decision on the most appropriate model for the situation
- Ingest hourly forecasts out to 48 hours
  - Output of 1, 3,6 and 24 hour precipitation accumulations (for FFG)
  - Produce Forecast Mean Areal Precipitation (FMAP) products
- Can ingest nowcasting products from SWFDP if available – just another model product

## RETURN

## RADAR INGESTION

In addition to satellite- and gauge- based precipitation can also ingest radar-based estimates

- Evaluate viable radars in the region – calibration status, data availability
- Develop clutter masking for areas blocked or show clutter
- Develop a bias adjustment procedure – climatological or dynamic (need good quality gauge data under radar umbrella)
- Develop a merged product as required
- Backup (blocked/clutter areas) is satellite

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