



# Overview of CARFFG System Products Part 1: Diagnostic Products

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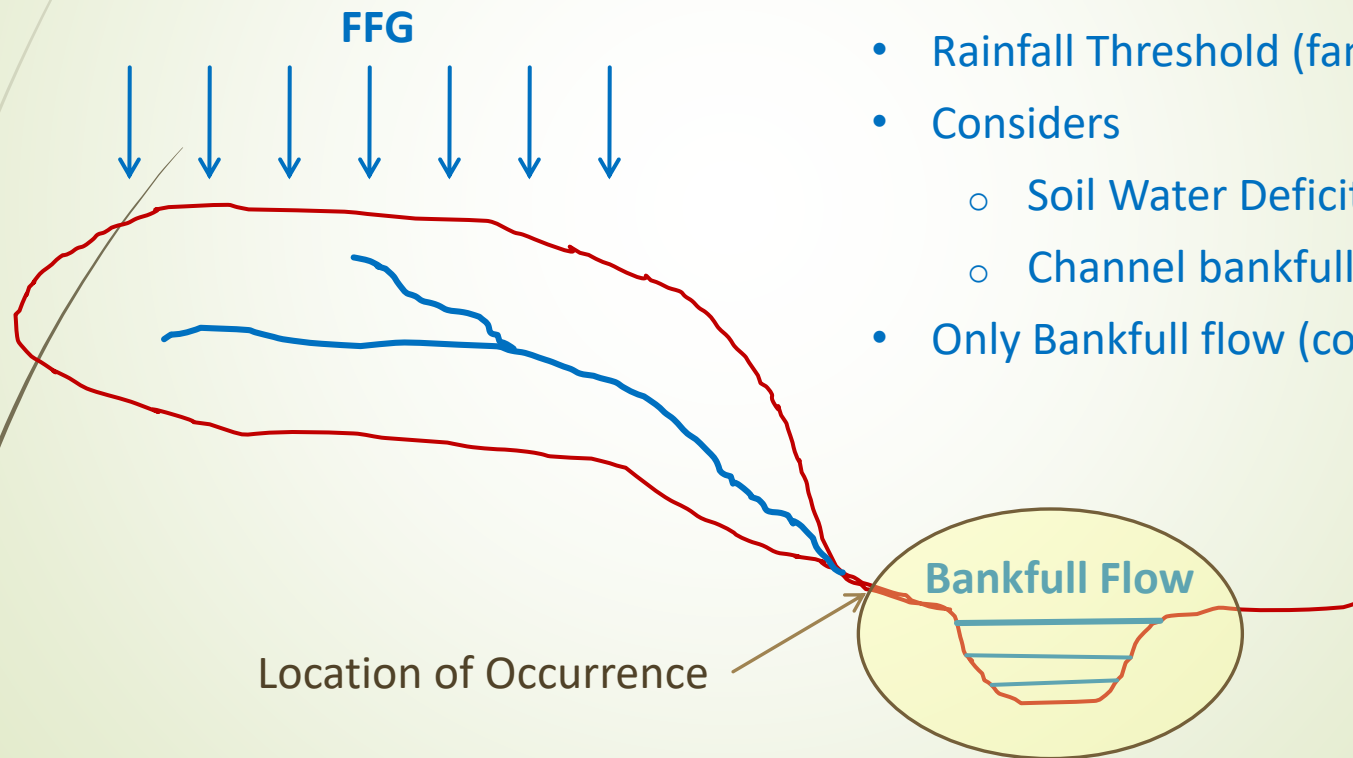
CARFFG SCM2

04-06 OCT 2016

Astana, KAZAKHSTAN

# FFG System Fundamental Concept

Flash Flood Guidance (FFG): defines the amount of **rainfall** of a given duration and over a given catchment that is just enough to cause **flooding conditions** at the outlet of the draining stream



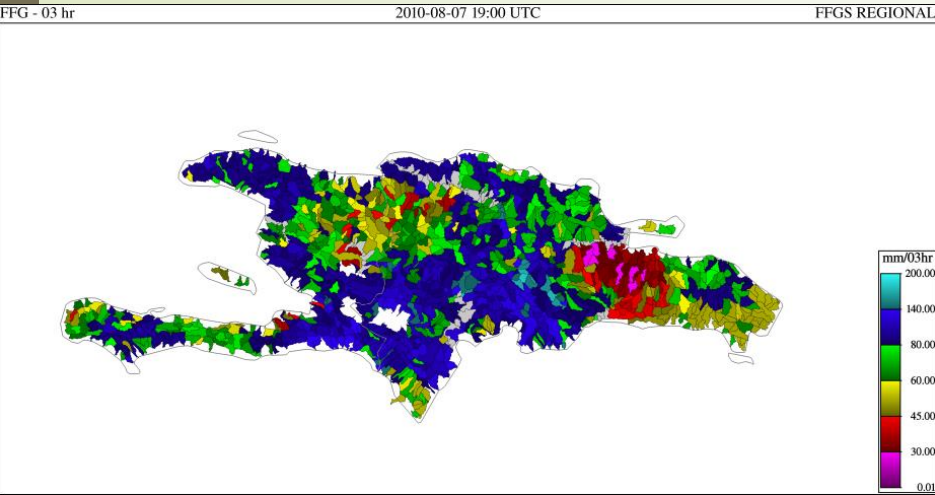
- Rainfall Threshold (familiar concept)
- Considers
  - Soil Water Deficit
  - Channel bankfull storage
- Only Bankfull flow (conservative)

**Threshold exceedance concept to estimate occurrence only!**

# FFG System Fundamental Concept

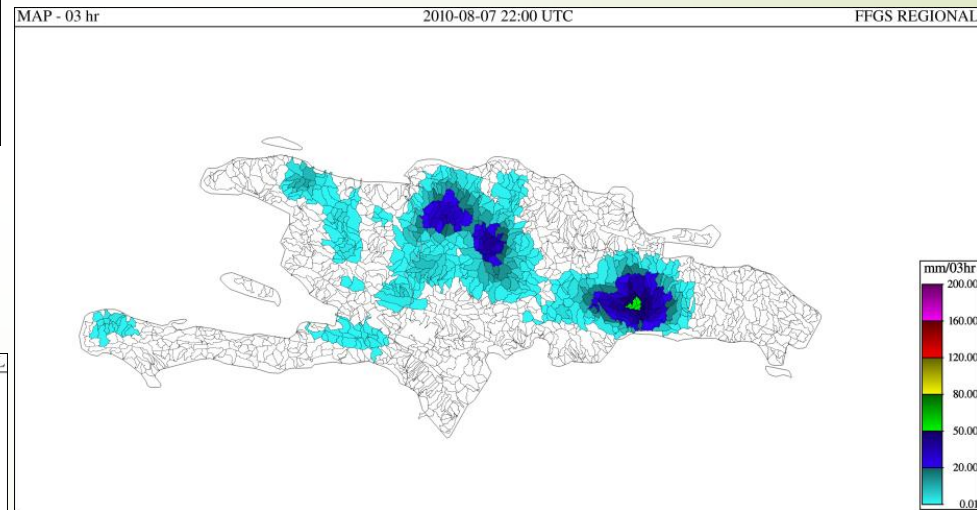
## REGIONAL APPLICATION OF FFG

[Example from the HDRFFG System]

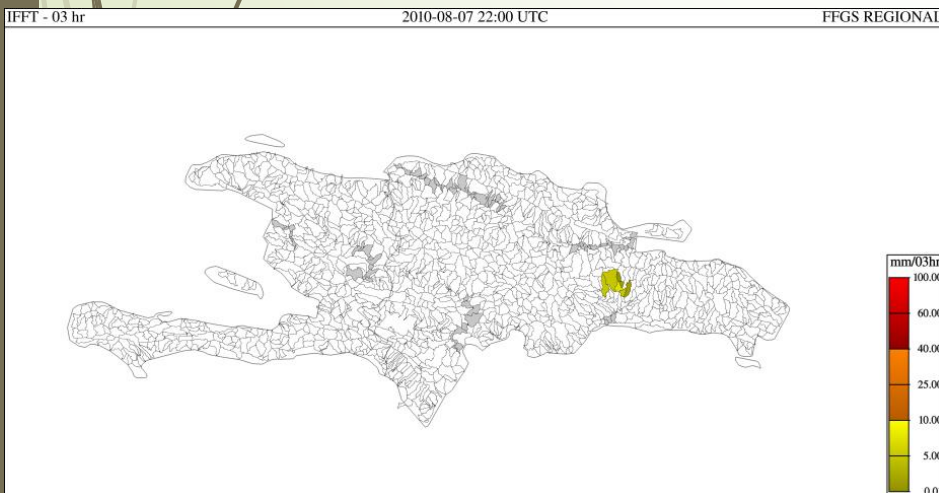


(1) Current Estimate of FFG for small watersheds

(2) Compare with precipitation (obs or forecast)



(3) Identify areas with  $P > FFG$

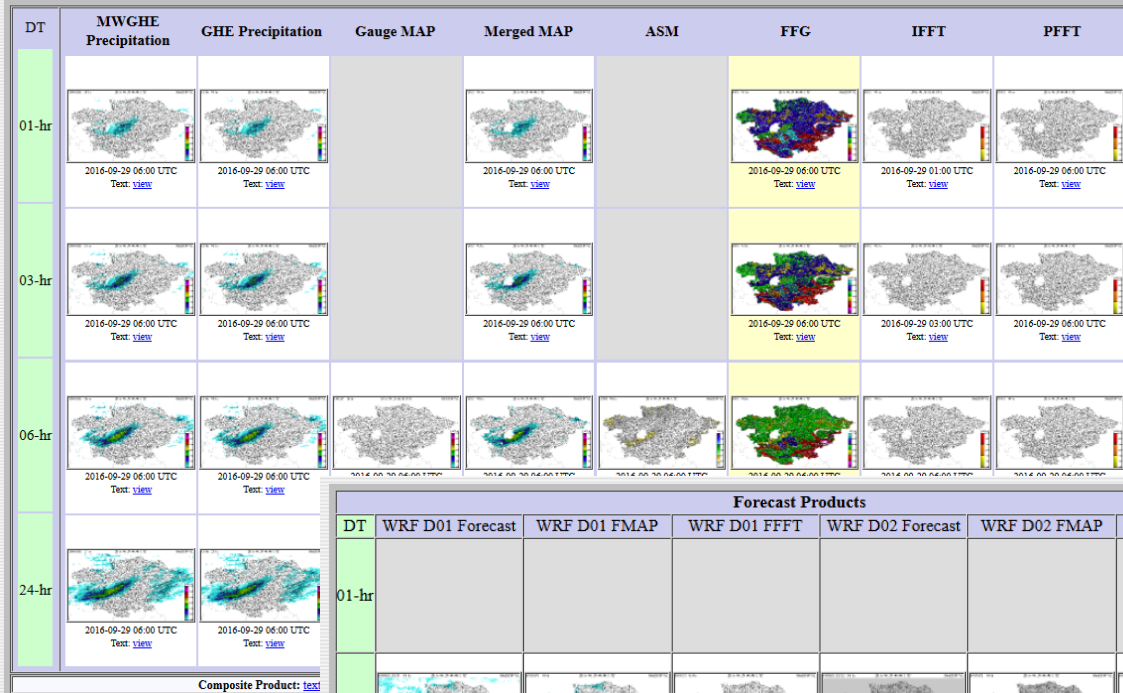


# CARFFG System Products

## CARFFG - Central Asia Regional Flash Flood Guidance System

The CARFFG System is presently being prepared for on-site deployment. During this preparation, the interface and displayed data contents availability may be sporadically interrupted should be considered a Beta Version.

**Current Date:** 2016-09-29 21:18 UTC      **Nav Date:** 2016-09-29 06:00 UTC  
 Year: 2016   Month: 09   Day: 29   Hour: 06   REGION: REGIONAL   Submit  
 -1 Month   -1 Day   -6 Hours   -1 Hour   +1 Hour   +6 Hours   +1 Day   +1 Month  
 Prev 6-hr Interval (00 UTC)   Reset to Current   Next 6-hr Interval (12 UTC)



Forecast Products						
DT	WRF D01 Forecast	WRF D01 FMAP	WRF D01 PFFT	WRF D02 Forecast	WRF D02 FMAP	WRF D02 PFFT
01-hr						
03-hr						
06-hr						
24-hr						

## DIAGNOSTIC

Flash Flood Guidance  
Average Soil Moisture  
Observed Precipitation  
Snow Products

## PROGNOSTIC

Forecast Precipitation (FMAP)  
Flash Flood Threat

# CARFFG Product Console

## CARFFG - Central Asia Regional Flash Flood Guidance System

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**Observed  
Precipitation**

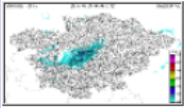
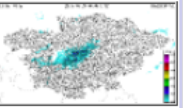
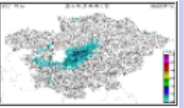
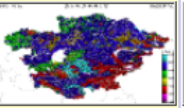
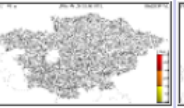
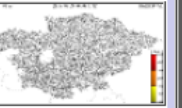
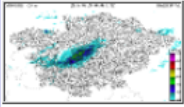
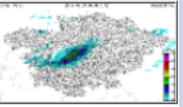
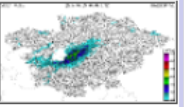
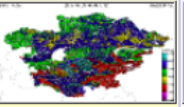
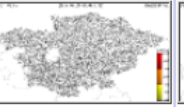
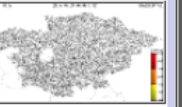
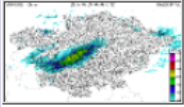
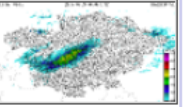
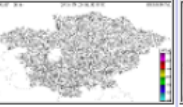
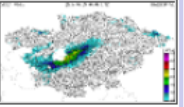
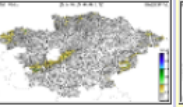
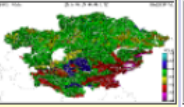
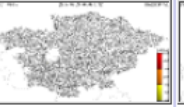
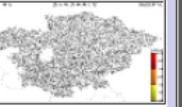
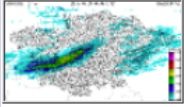
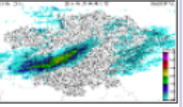
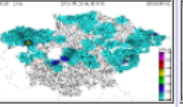
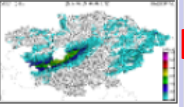
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Nav Date: 2016-09-29 06:00 UTC

Year: 2016 Month: 09 Day: 29 Hour: 06 REGION: REGIONAL Submit

-1 Month -1 Day -6 Hours -1 Hour +1 Hour +6 Hours +1 Day +1 Month

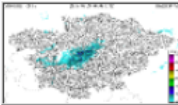
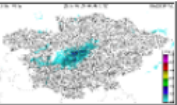
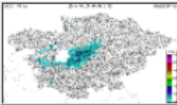
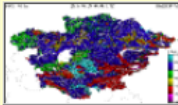
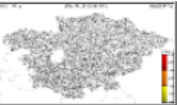

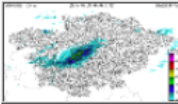
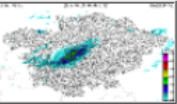
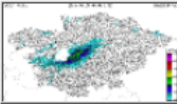
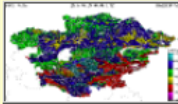

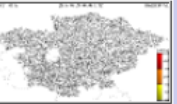
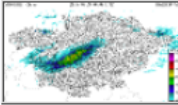
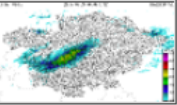

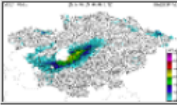
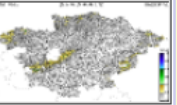
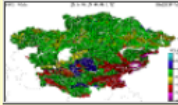
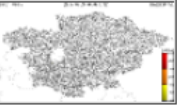

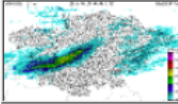
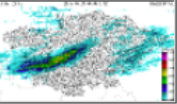
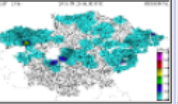
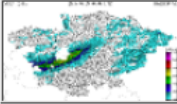
Prev 6-hr Interval (00 UTC) Reset to Current Next 6-hr Interval (12 UTC)

DT	MWGHE Precipitation	GHE Precipitation	Gauge MAP	Merged MAP	ASM	FFG	IFFT	PFFT
01-hr	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>		 2016-09-29 06:00 UTC <a href="#">Text: view</a>		 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 01:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>
03-hr	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>		 2016-09-29 06:00 UTC <a href="#">Text: view</a>		 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 03:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>
06-hr	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>
24-hr	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	 2016-09-29 06:00 UTC <a href="#">Text: view</a>	<b>Hydrologic State (Land Surface)</b>			

# CARFFG Product Console

## CARFFG - Central Asia Regional Flash Flood Guidance System

*Flash Flood Guidance Systems need up-to-date high-quality estimates of precipitation to assess current flash flood potential.*

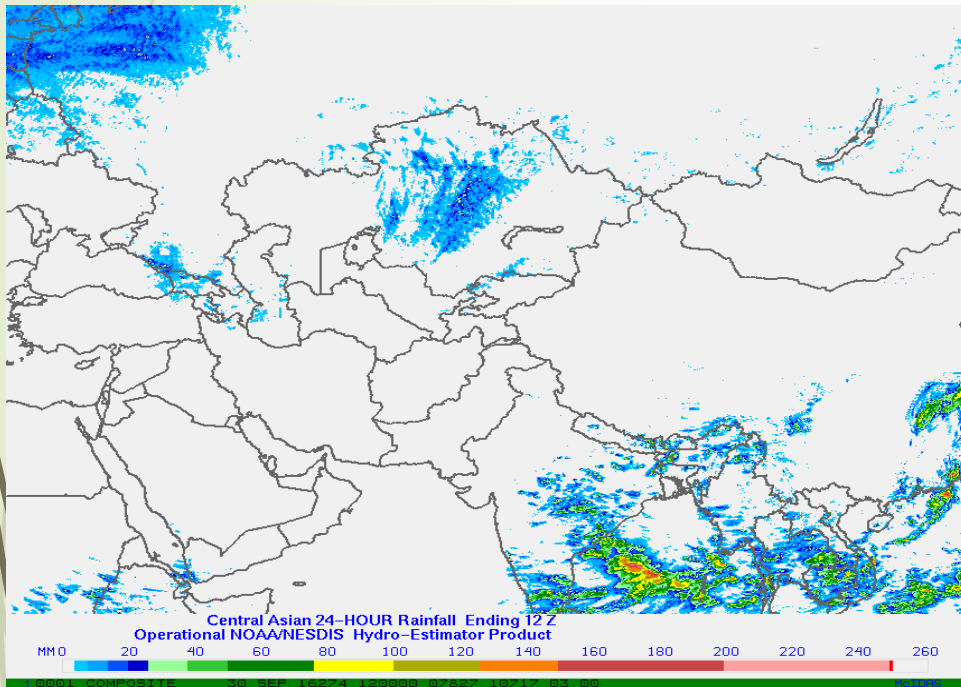
DT	MWGHE Precipitation	GHE Precipitation	Gauge MAP	Merged MAP	ASM	FFG	IFFT	PFFT
01-hr	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>		 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>		 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 01:00 UTC Text: <a href="#">view</a></p>	 <p>2016-09-29 06:00 UTC Text: <a href="#">view</a></p>
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 03:00 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>	 <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>				

# Satellite Precipitation – HydroEstimator (GHE)

Remotely-sensed precipitation estimates provide good spatial coverage and detail.  
In situ observations (rain gauges) provide “ground truth” but often have sparse coverage.

NOAA/NESDIS Hydro-Estimator

24-hr rainfall ending 30-Sep-2016 @ 12 UTC



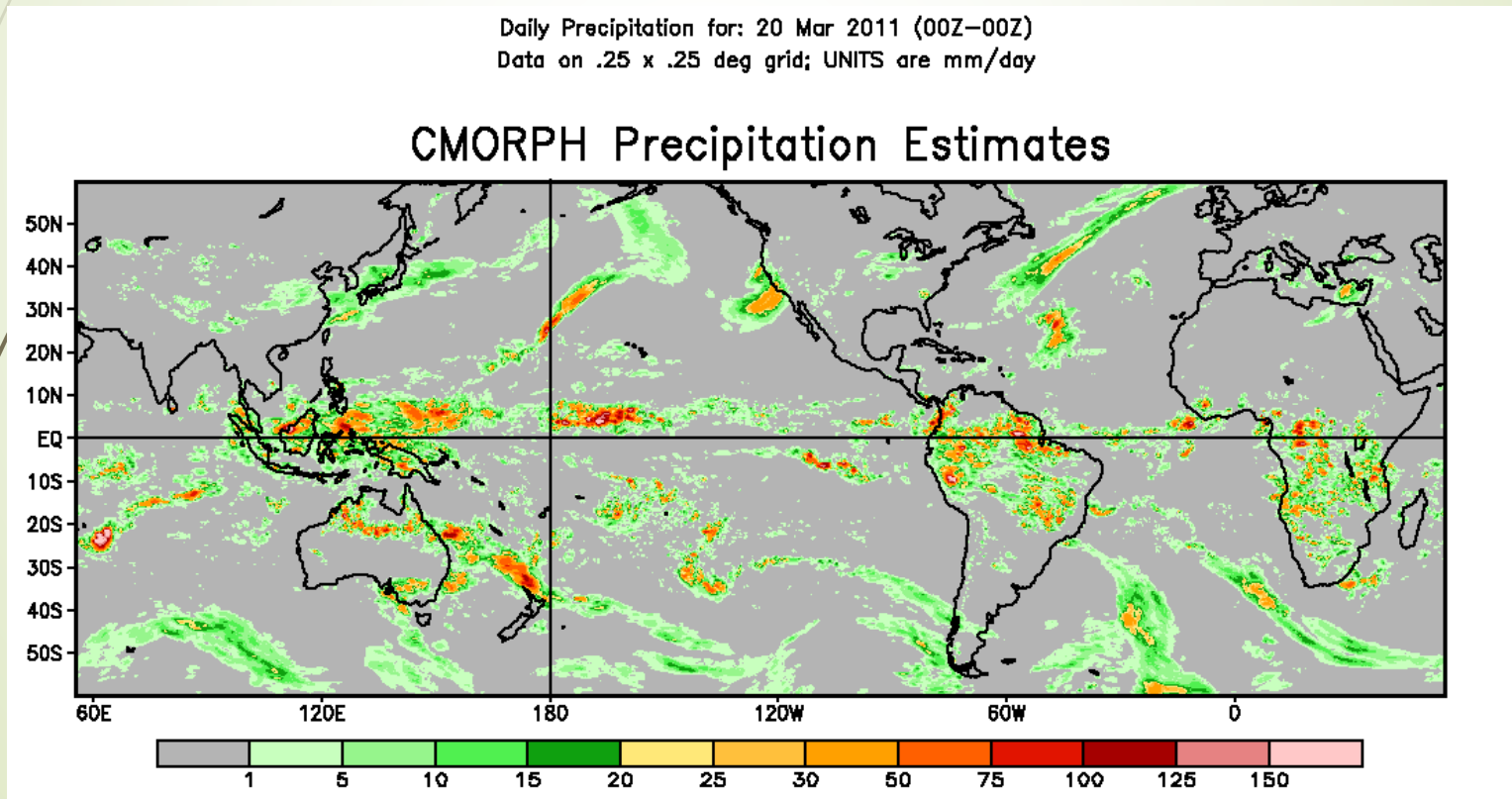
- ❖ Satellite estimates since 1970s; Hydro-Estimator since 2002; GHE operational in 2012.
- ❖ Provide critical data in data sparse regions!
- ❖ Infrared (IR) based (10.7  $\mu\text{m}$ )
- ❖ **\*\*Short latency\*\*** (< ½ hour)
- ❖ ~4 km resolution

GHE: Rainfall rate based on Cloud Top Brightness Temperature (*indirect measurement*)

# Multi-Spectral Satellite Precipitation for FFG Systems

CMORPH is based on measurements of microwave scattering from raindrops.

- measure of the hydrometeors in clouds
- still not observation of rainfall at surface
- ~8 km resolution
- 18-26 hr latency in operations



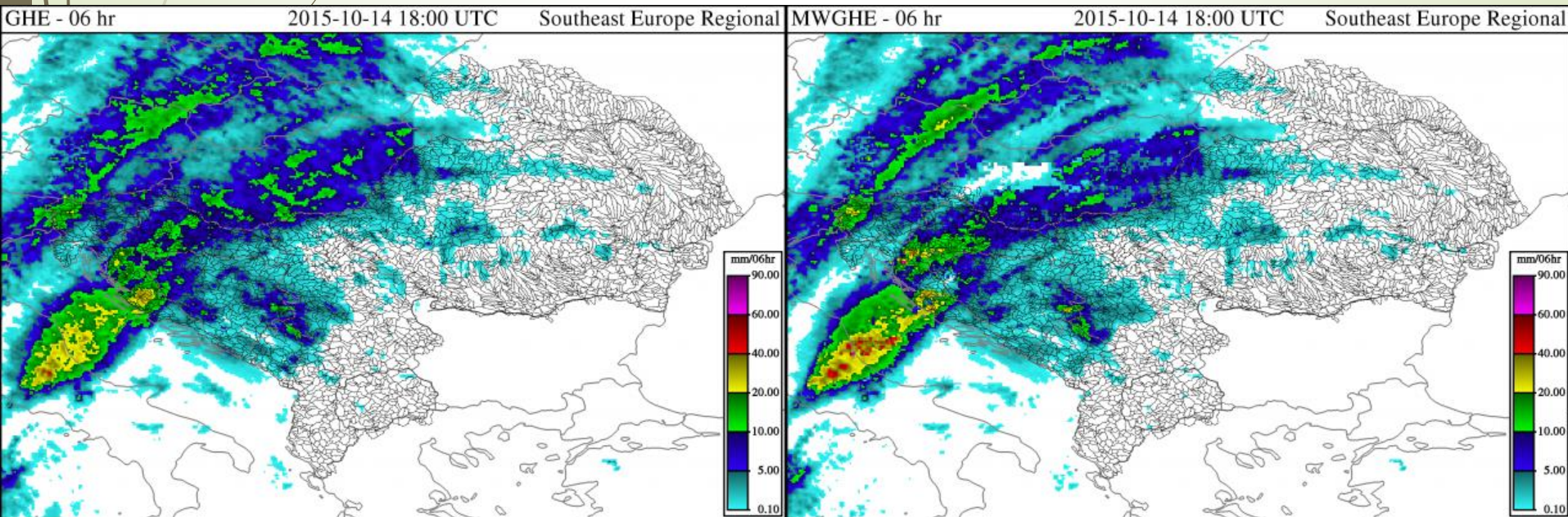


# FFG System Product: MWGHE

## *HRC effort to combine IR-based GHE rainfall with MW-based CMORPH rainfall*

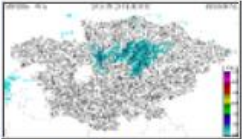
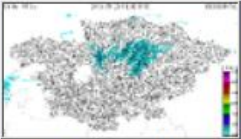
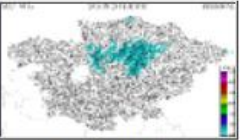
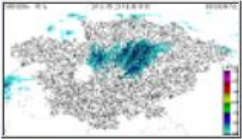
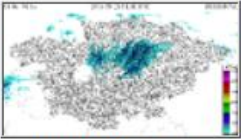
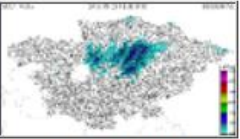
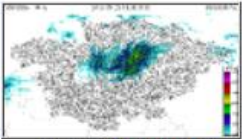
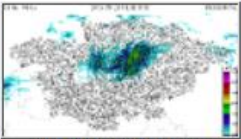
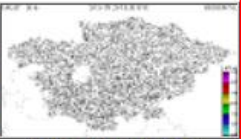
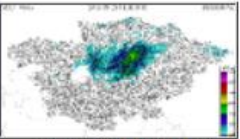
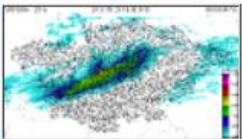
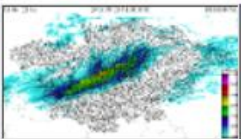
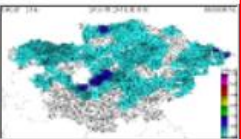
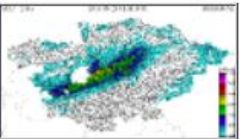
HRC-developed method which:

- compares IR-based GHE and MW-based CMORPH for period (2-3 days) up to last CMORPH observation,
- develops an adjustment factor based on differences within region,
- applies adjustment to GHE up to current observation.



Example from South East Europe (SEFFGS)

# Merged MAP Product

DT	MWGHE Precipitation	GHE Precipitation	Gauge MAP	Merged MAP
01-hr	 2016-09-29 18:00 UTC Text: <a href="#">view</a>	 2016-09-29 18:00 UTC Text: <a href="#">view</a>		 2016-09-29 18:00 UTC Text: <a href="#">view</a>
03-hr	 2016-09-29 18:00 UTC Text: <a href="#">view</a>	 2016-09-29 18:00 UTC Text: <a href="#">view</a>		 2016-09-29 18:00 UTC Text: <a href="#">view</a>
06-hr	 2016-09-29 18:00 UTC Text: <a href="#">view</a>	 2016-09-29 18:00 UTC Text: <a href="#">view</a>	 2016-09-29 18:00 UTC Text: <a href="#">view</a>	 2016-09-29 18:00 UTC Text: <a href="#">view</a>
24-hr	 2016-09-29 18:00 UTC Text: <a href="#">view</a>	 2016-09-29 18:00 UTC Text: <a href="#">view</a>	 2016-09-29 18:00 UTC Text: <a href="#">view</a>	 2016-09-29 18:00 UTC Text: <a href="#">view</a>

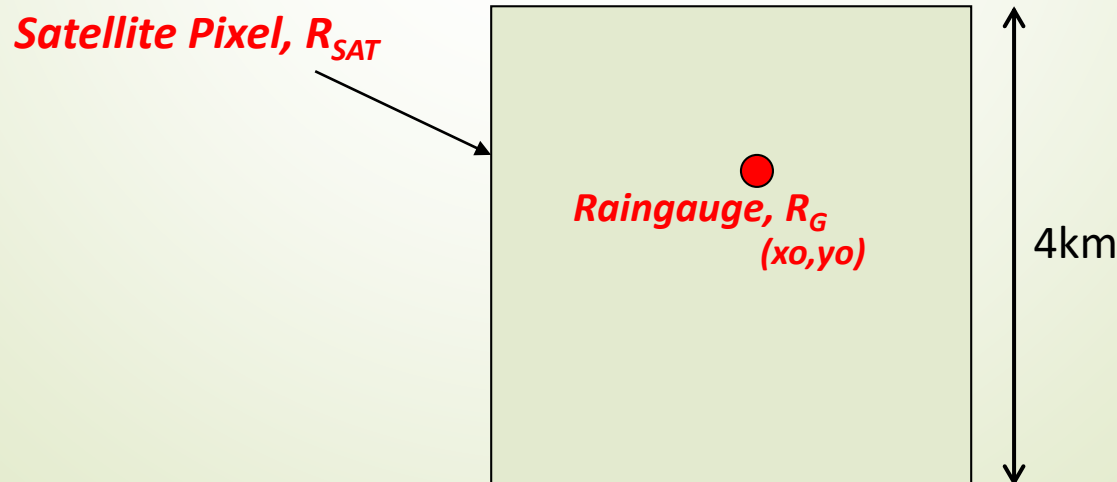
Merged MAP is the *best estimate* of Mean Areal Precipitation over each small watershed for previous 1-, 3-, 6- and 24- hour periods.

- Satellite
- Real-time gauges
- Radar (if available)
- \* Includes bias adjustment

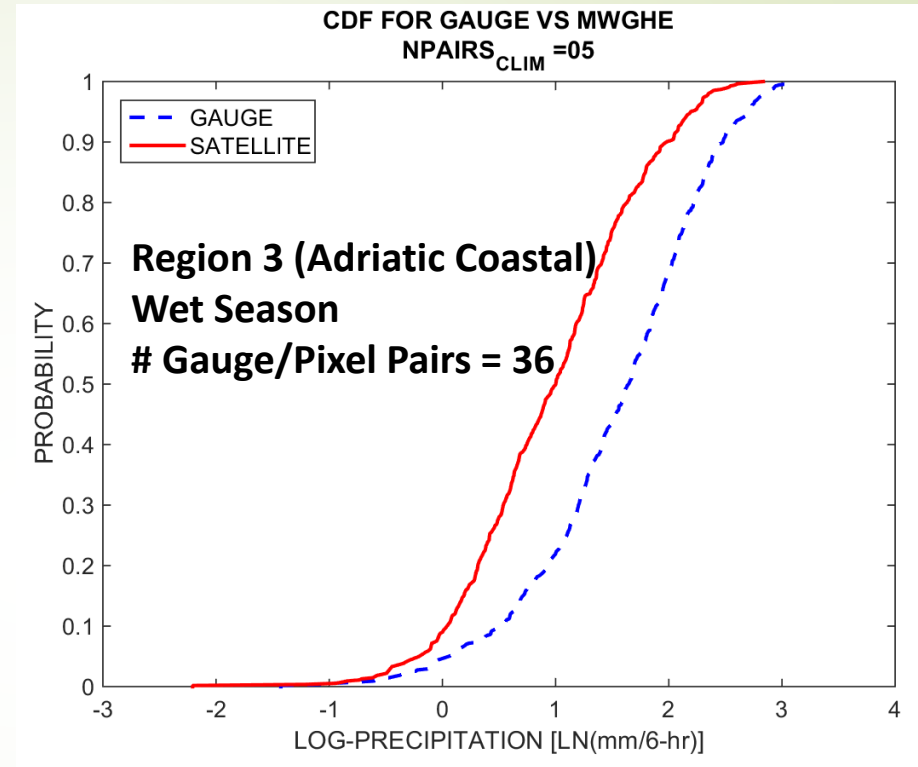
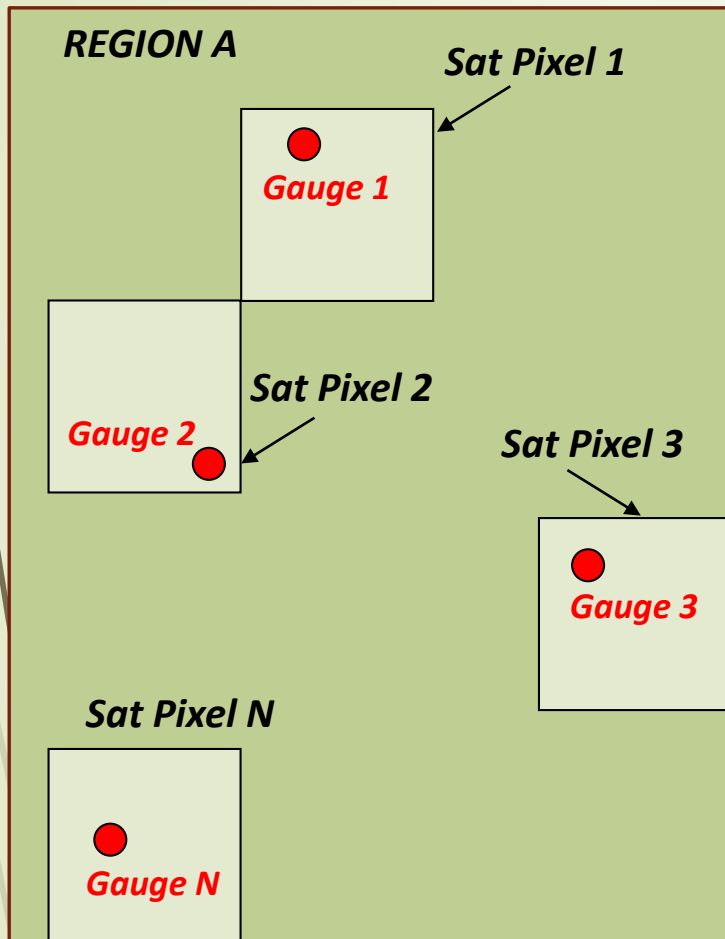
# Bias Adjustment for Satellite Precipitation

*Bias may exist in the remotely sensed precipitation estimates relative to gauges. Bias should be removed before inputting to hydrologic models.*

- ❖ Vastly different scales of satellite pixel and rain gauge area
- ❖ Orography organizes surface rainfall according to prevailing winds
- ❖ Satellite estimates do not directly measure rainfall at surface
- ❖ There may be significant misregistration errors in satellite data



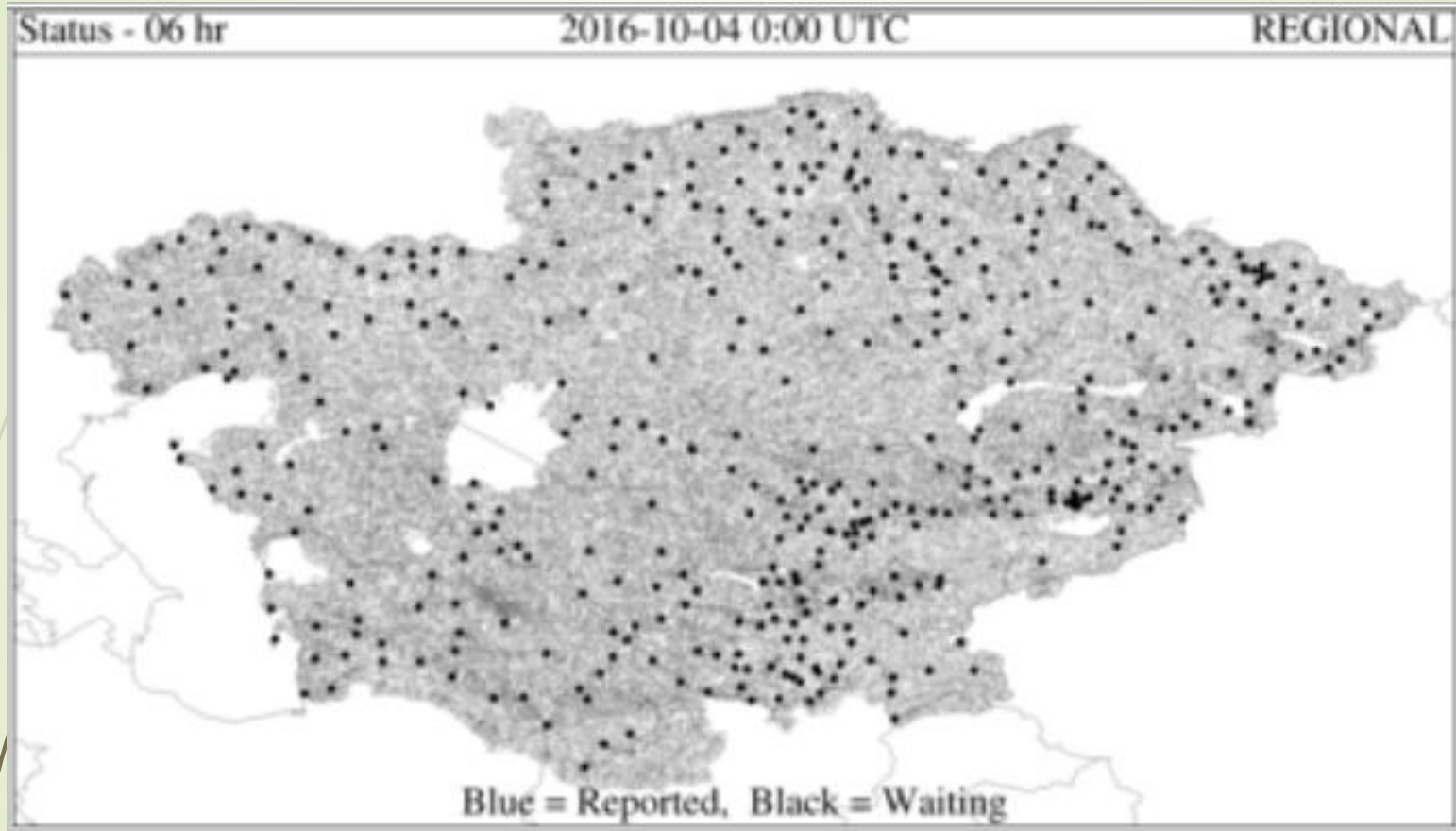
# Bias Adjustment for Satellite Precipitation



$$\text{Log Bias: } \beta_t = \ln \left\{ \frac{\sum_{j=1}^{N_G} R_G(j, t) / N_G}{\sum_{j=1}^{N_G} R_{SAT}(j, t) / N_G} \right\}$$

*Two bias adjustments may be made: climatological and real-time.*

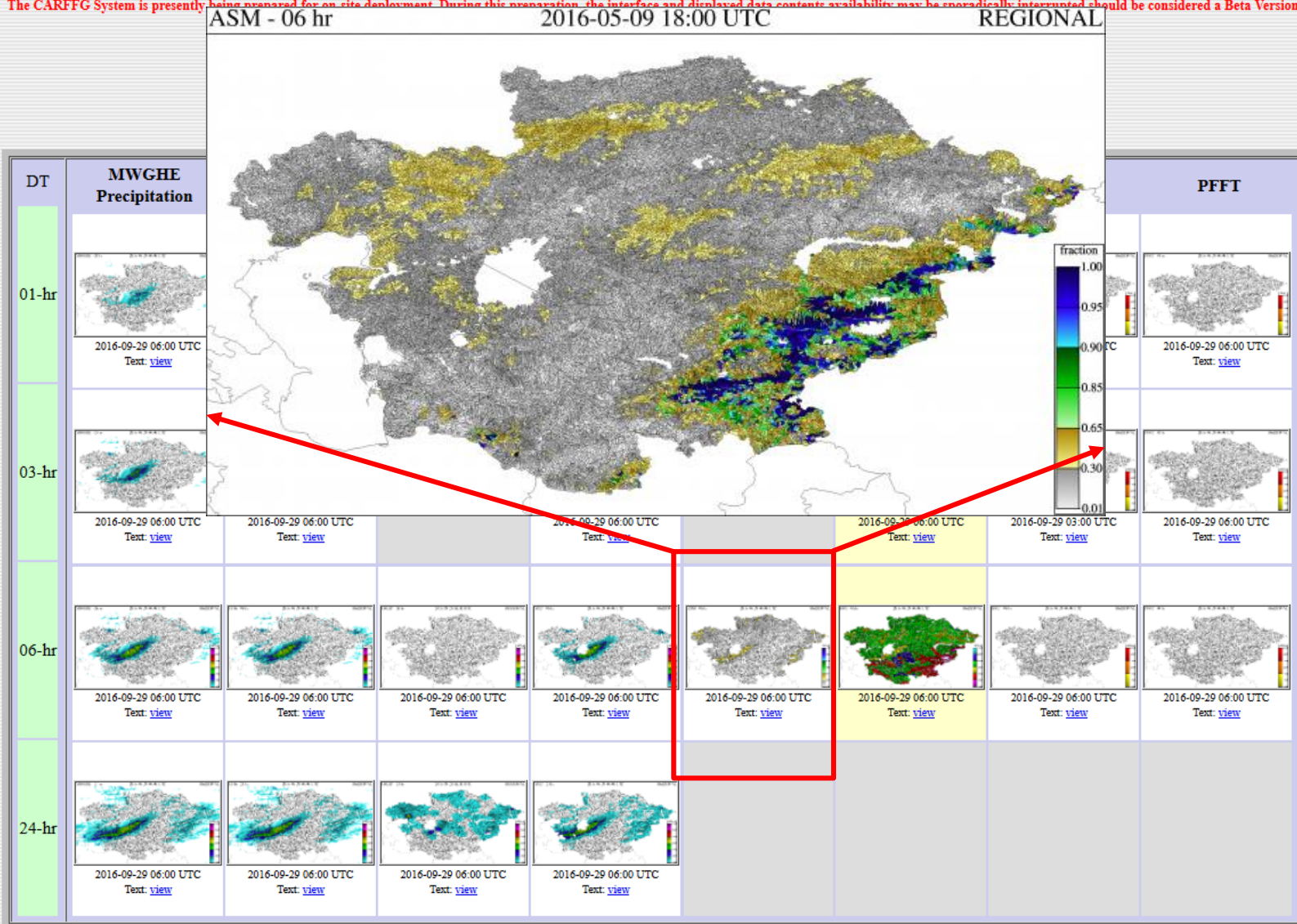
# Real Time Precipitation Stations for Bias Adjustment



# CARFFG Product Console

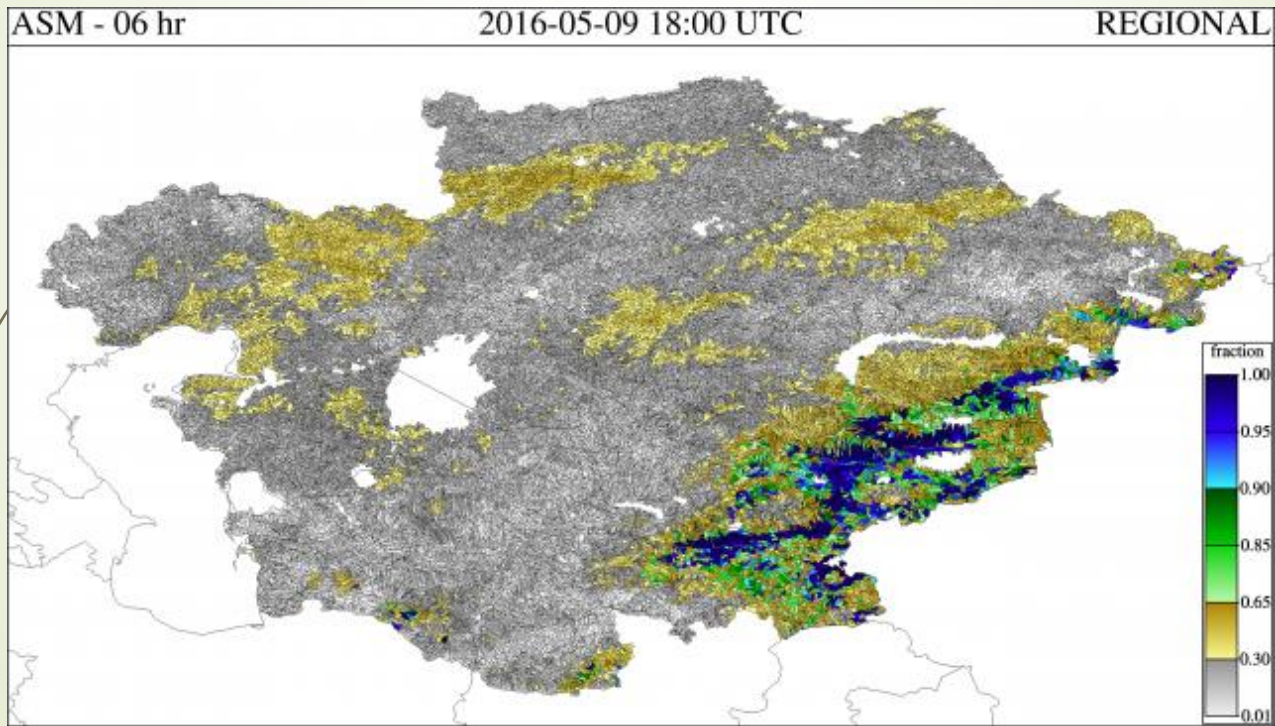
## CARFFG - Central Asia Regional Flash Flood Guidance System

The CARFFG System is presently being prepared for on-site deployment. During this preparation, the interface and displayed data contents availability may be sporadically interrupted, should be considered a Beta Version.



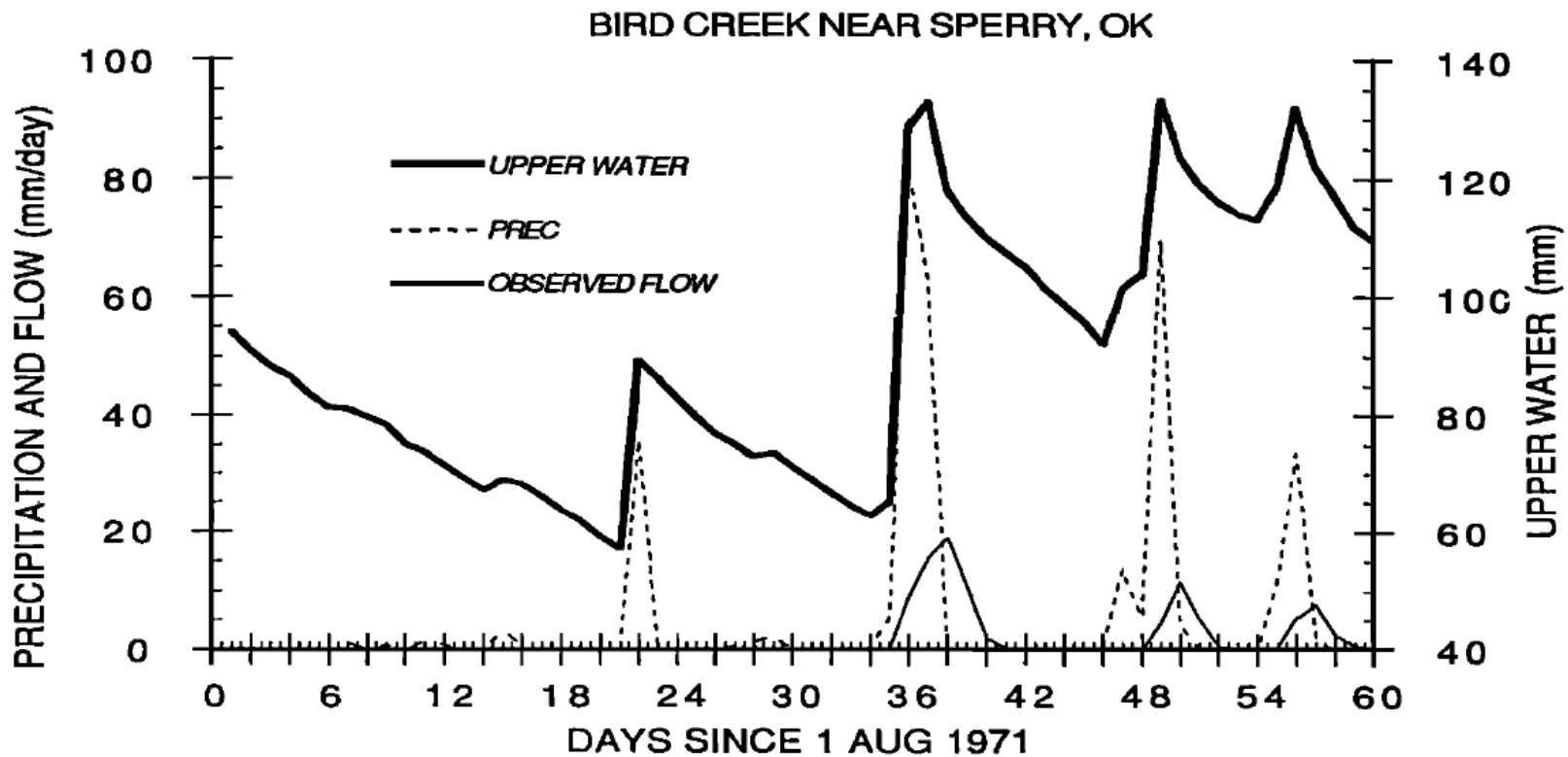
# ASM: Average Soil Moisture

An estimate of the level of saturation (fraction) in the upper soil layer. This is computed by the model.



# Why is Soil Moisture Important?

GEORGAKAKOS ET AL.: HYDROCLIMATOLOGY OF WATERSHEDS, 1



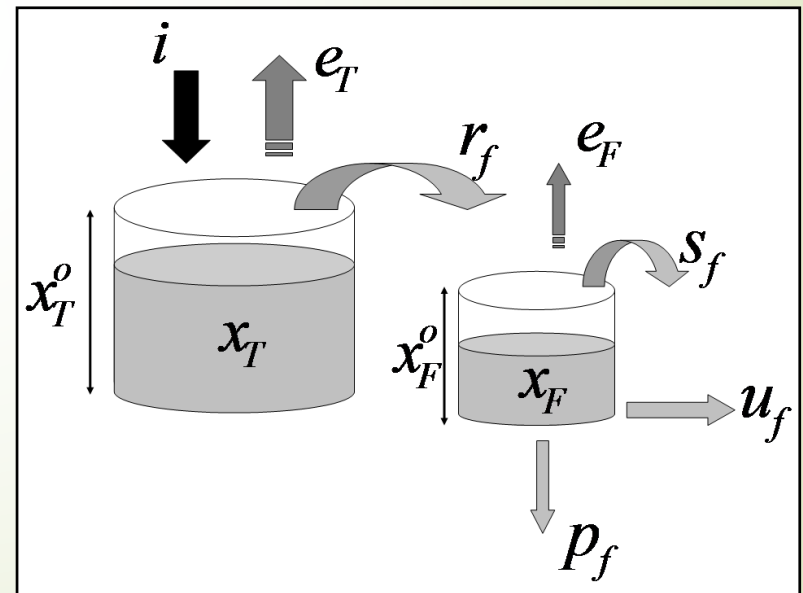
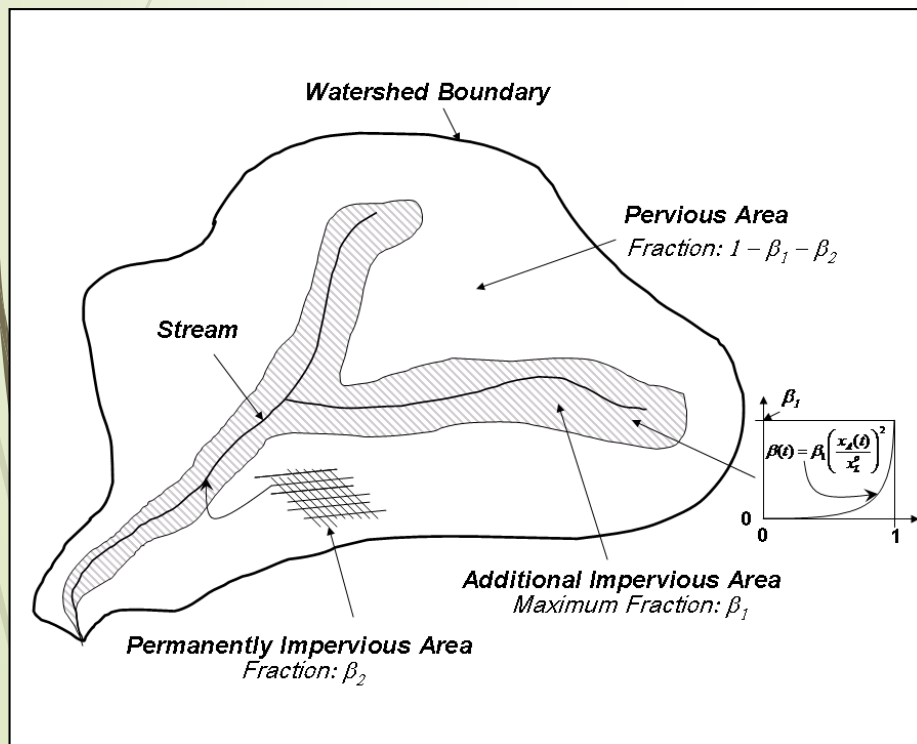
**Figure 2.** Daily values of rainfall rate (dashed line), flow rate (solid line), and upper soil water (heavy solid line) for Bird Creek near Sperry, Oklahoma, for August and September 1971. Rainfall and flow rates are in millimeters per day and are read on the left ordinate axis. Upper water is in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



# Soil Water Modeling for CARFFG

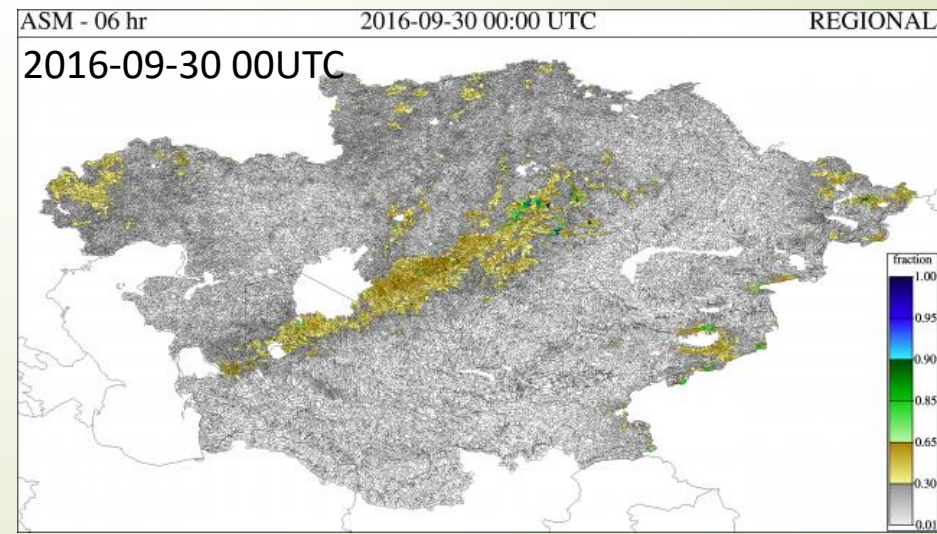
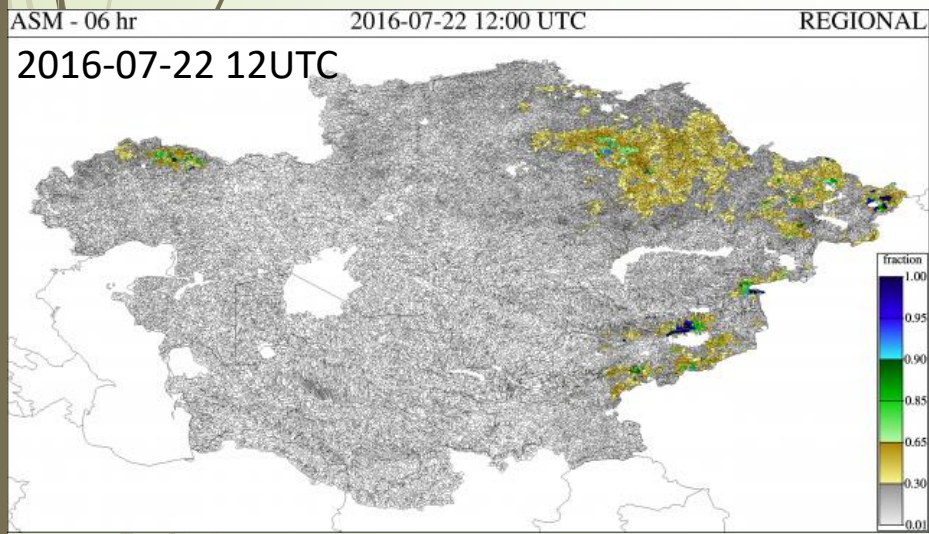
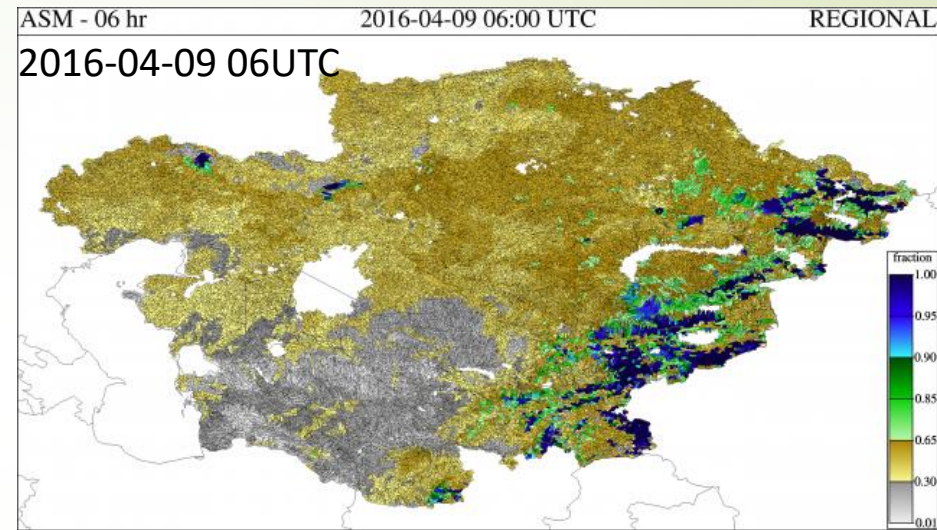
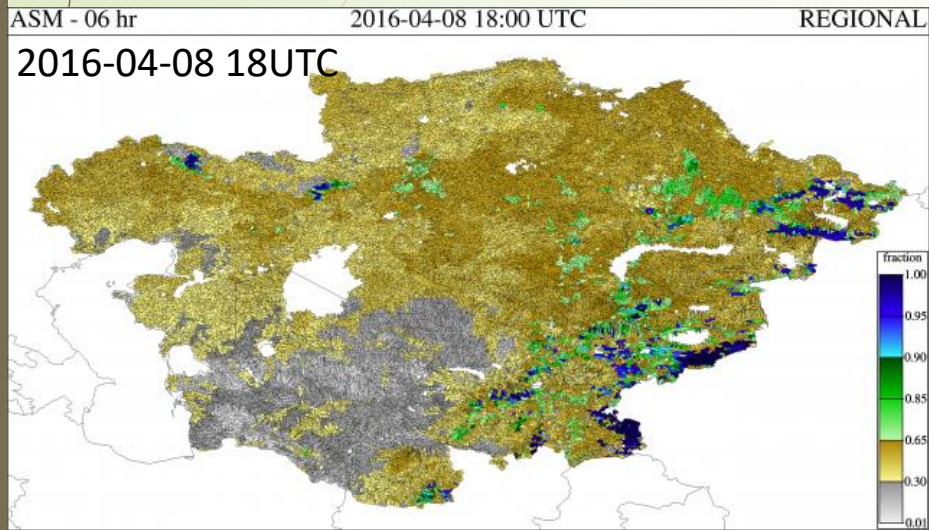
A conceptual lumped hydrologic model is used for modeling of soil water for each small watershed.

*A two-layer conceptual representation of the movement of soil water through a vertical, homogeneous soil column using the Sacramento Soil Moisture Accounting Model (SAC-SMA).*



# Temporal Variation in Average Soil Moisture

Forecaster will see changes as precipitation falls and basins (or groups of basins) become more saturated. ASM is updated every 6 hours.



# CARFFG Product Console

## CARFFG - Central Asia Regional Flash Flood Guidance System

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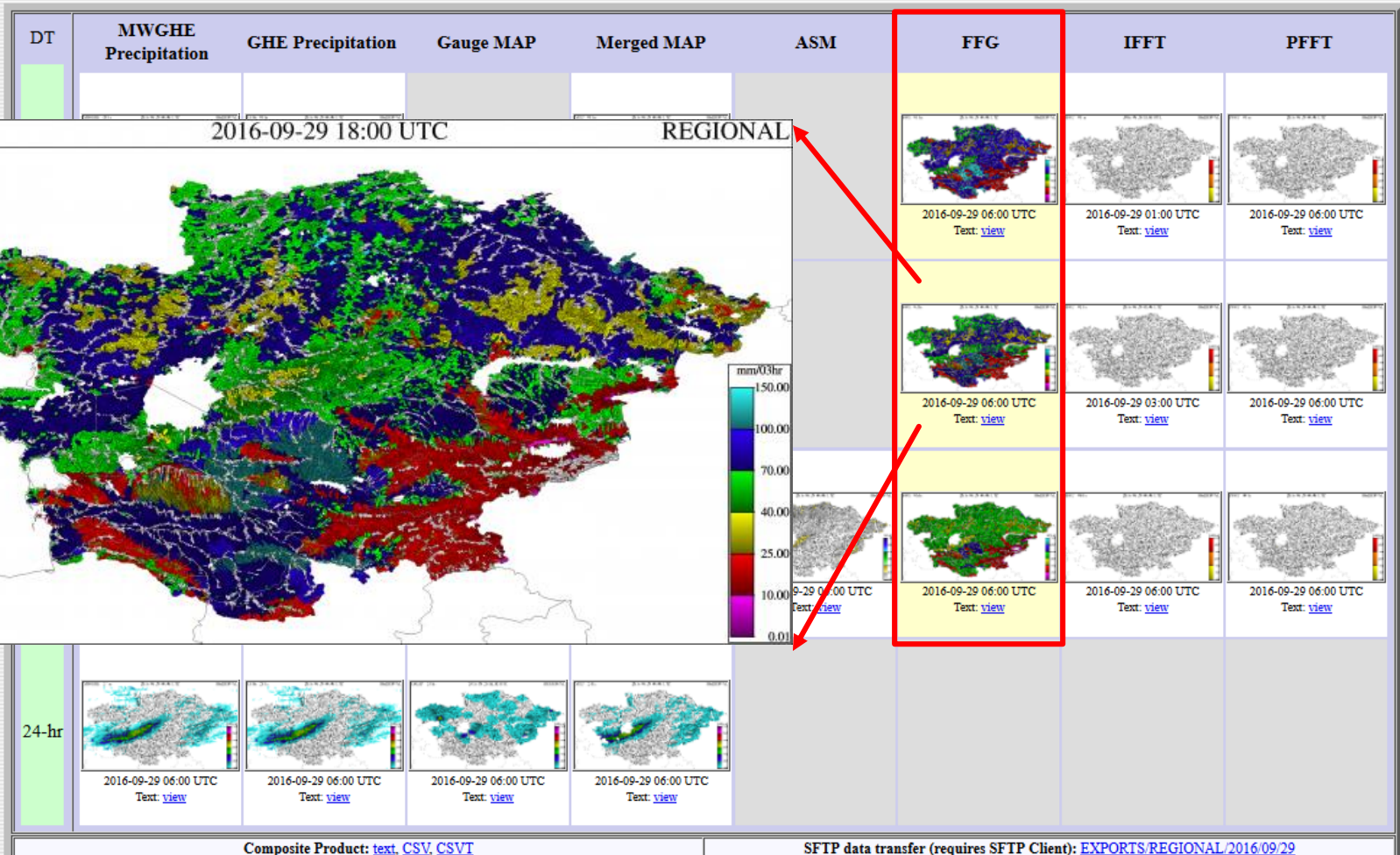
Current Date: 2016-09-29 21:18 UTC

Nav Date: 2016-09-29 06:00 UTC

Year: 2016 Month: 09 Day: 29 Hour: 06 REGION: REGIONAL Submit

-1 Month -1 Day -6 Hours -1 Hour +1 Hour +6 Hours +1 Day +1 Month

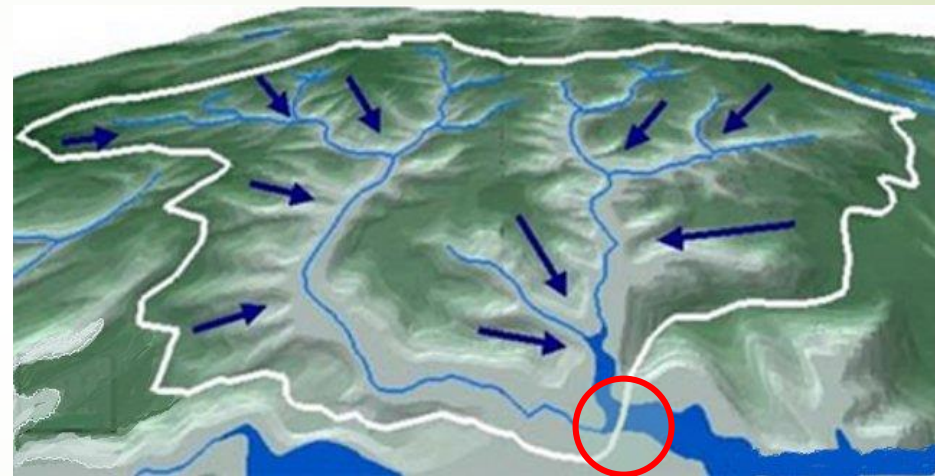
Prev 6-hr Interval (00 UTC) Reset to Current Next 6-hr Interval (12 UTC)



# Definition of Flash Flood Guidance

Flash Flood Guidance (FFG): The amount of **rainfall** of a given duration and over a given catchment that is just enough to cause **bankfull conditions** at the outlet of the draining stream.

FFG ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓



FFG considers


- Soil Water Deficit
- Channel storage at bankfull as defined by threshold runoff and regionalization of channel characteristics
- Only bankfull flow (conservative)



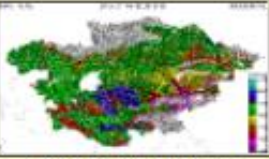
# FFG: Flash Flood Guidance

System computes *current* FFG values for each small watershed for rainfall durations of 1-, 3- and 6- hours. Updated every 6 hours.


**FFG**



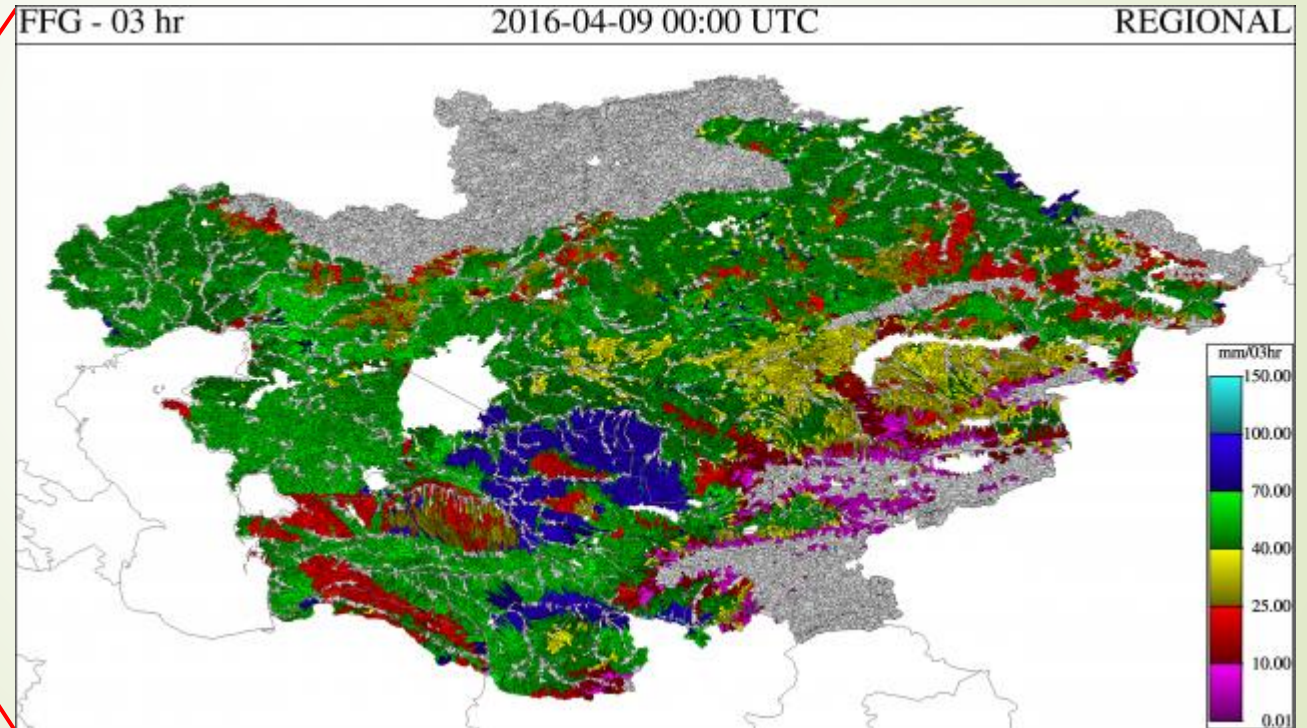
2016-04-09 00:00 UTC  
Text: [view](#)



2016-04-09 00:00 UTC  
Text: [view](#)



2016-04-09 00:00 UTC  
Text: [view](#)



# CARFFG Product Console

## CARFFG - Central Asia Regional Flash Flood Guidance System

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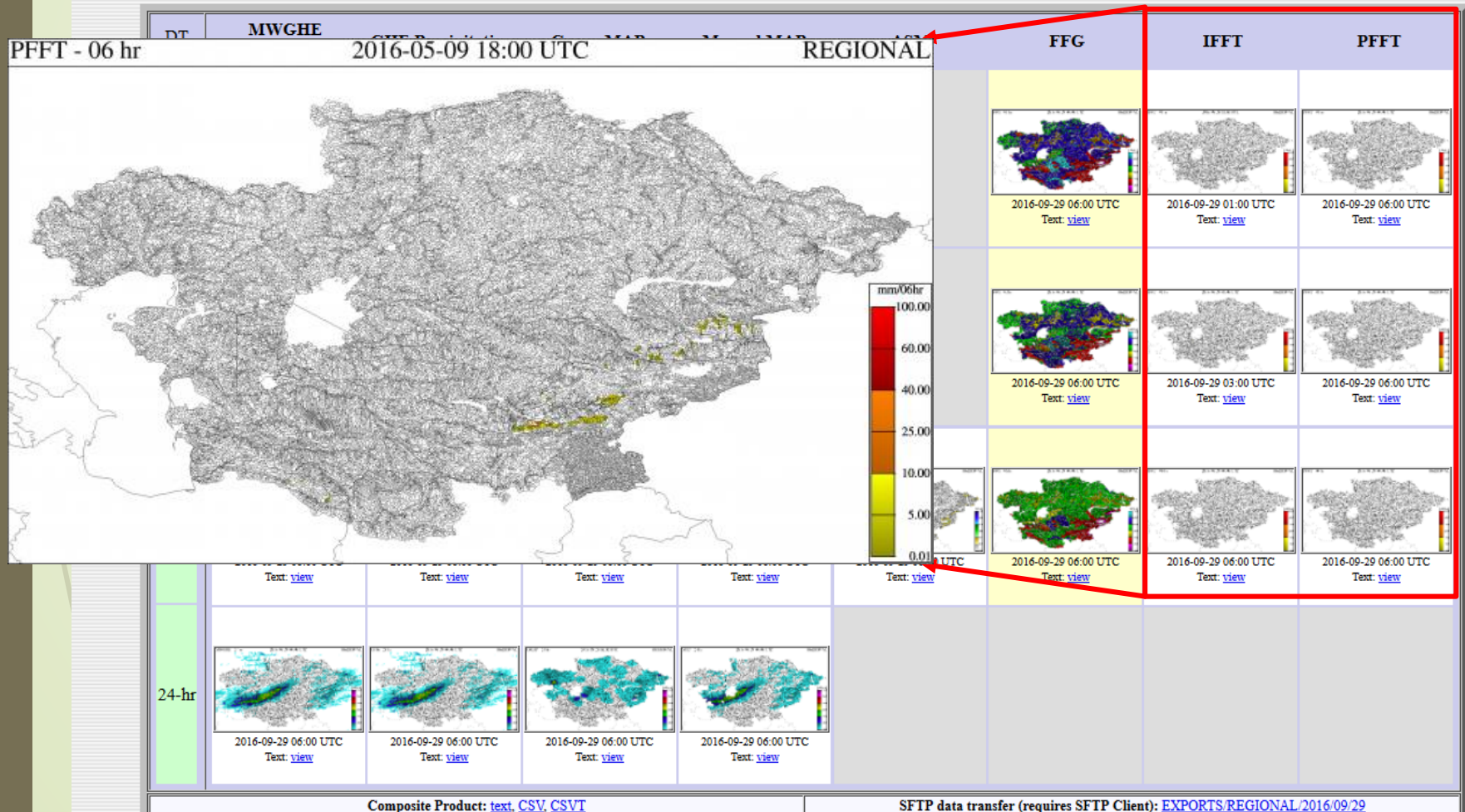
Current Date: 2016-09-29 21:18 UTC

Nav Date: 2016-09-29 06:00 UTC

Year: 2016 Month: 09 Day: 29 Hour: 06 REGION: REGIONAL Submit

-1 Month -1 Day -6 Hours -1 Hour +1 Hour +6 Hours +1 Day +1 Month

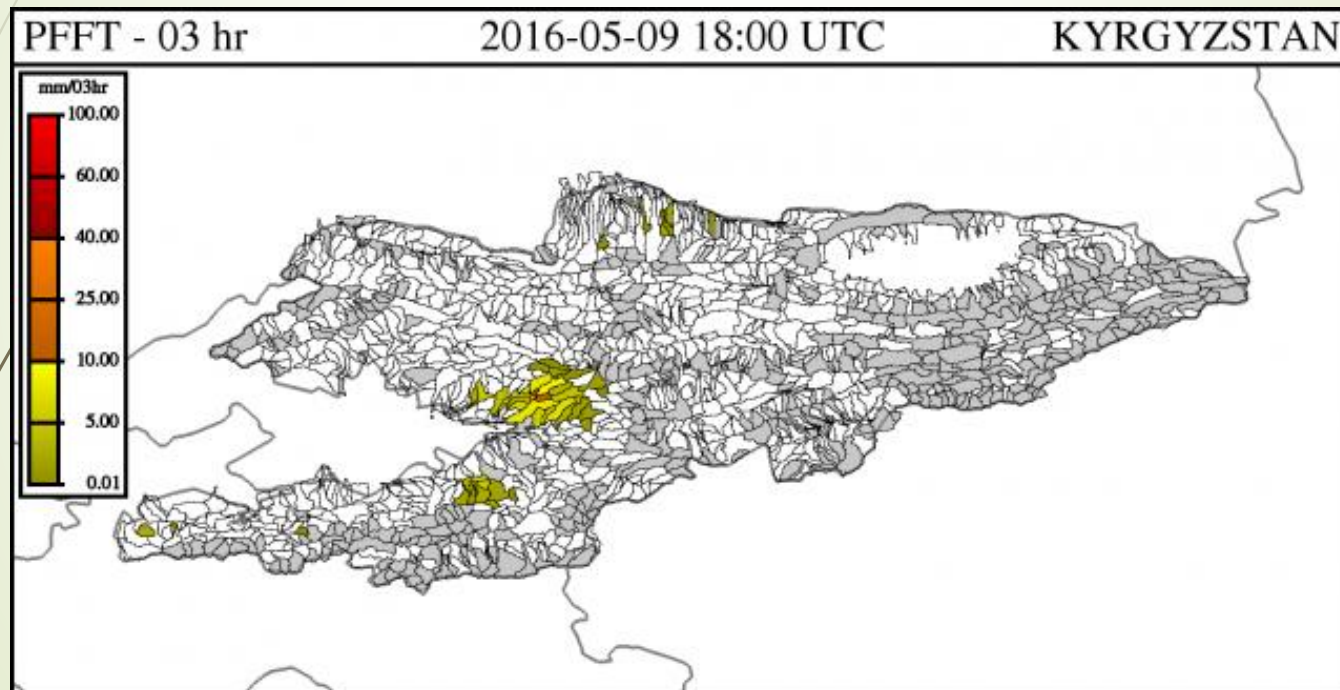
Prev 6-hr Interval (00 UTC) Reset to Current Next 6-hr Interval (12 UTC)



# FFT: Flash Flood Threat

Potential for flash flooding is increased when ***PRECIPITATION > FFG***.

*Flash Flood Threat, FFT, defined: **FFT = MAP - FFG***



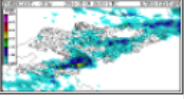
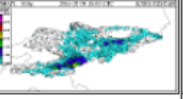

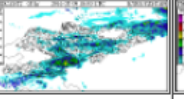
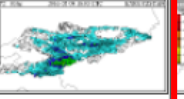
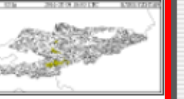
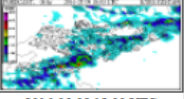
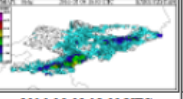

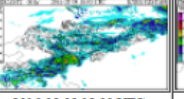
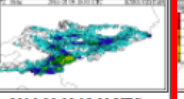

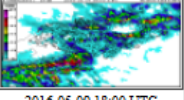
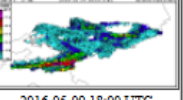
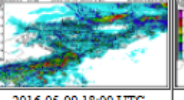
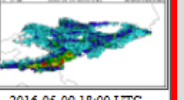
*FFT provides indication of regions of potential concern.  
Color bar provides magnitude of FFT.*

# CARFFG System Products: FFTs

## CARFFG - Central Asia Regional

The CARFFG System is presently being prepared for on-site deployment. During this preparation, the interface appears as follows:

Current Date: 2016-10-01 01:32 UTC  
 Year: 2016 Month: 05 Day: 09 Hour: 18  
 -1 Month -1 Day -6 Hours -1 Hour +1 Hour  
 Prev 6-hr Interval (12 UTC) Reset to Current Date

		Forecast Products					
DT		WRF D01 Forecast	WRF D01 FMAP	WRF D01 FFT	WRF D02 Forecast	WRF D02 FMAP	WRF D02 FFT
01-hr							
03-hr		 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>
06-hr		 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>
24-hr		 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>		 2016-05-09 18:00 UTC <a href="#">Text: view</a>	 2016-05-09 18:00 UTC <a href="#">Text: view</a>	

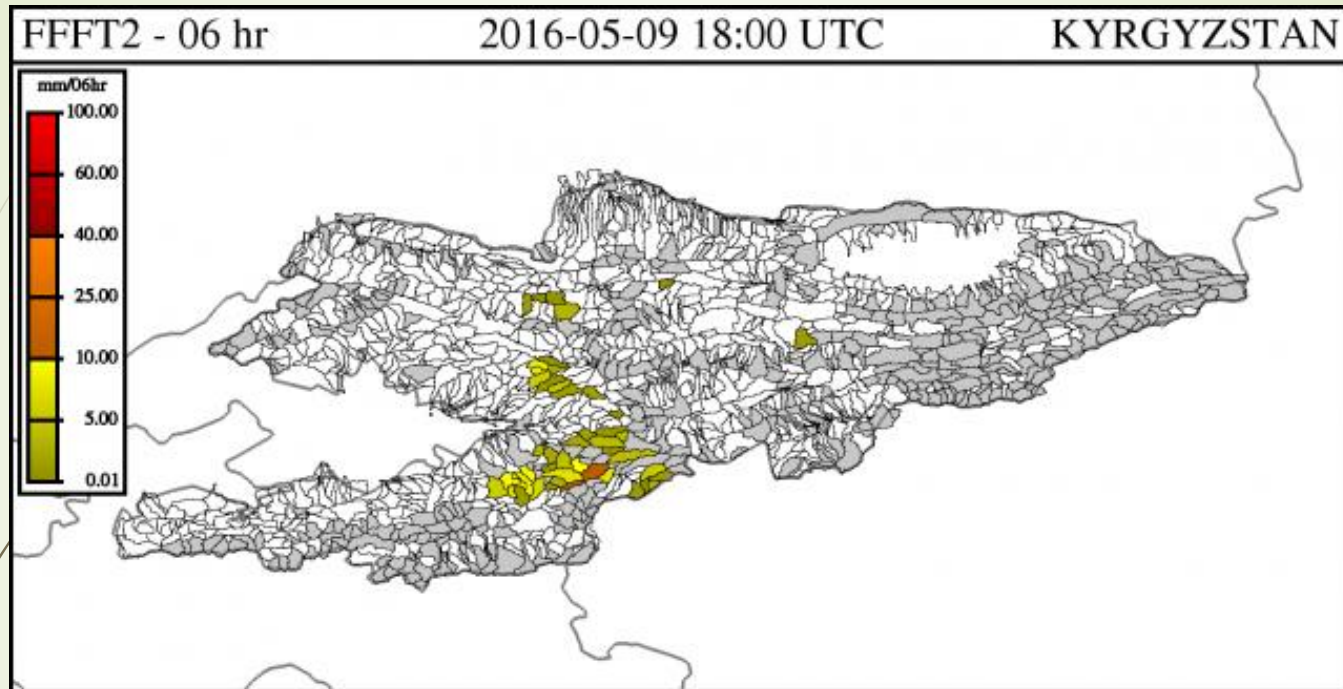
2016-05-09 18:00 UTC [Text: view](#) 2016-05-09 18:00 UTC [Text: view](#) 2016-05-09 18:00 UTC [Text: view](#) 2016-05-09 18:00 UTC [Text: view](#)

**Different FFT products are provided, based on observed or forecasted precipitation and timing.**

- IFFT: imminent, based on observed precipitation that has fallen.  
*Flash flooding may be occurring!*
- PFFT: forecast of persistence – IF rainfall continues at current rate
- FFT: based on forecast precipitation.



# Flash Flood Threat Products



*Operational forecasters recognize FFG System products and precipitation forecasts carry uncertainty, and must evaluate the current situation and forecast.*

*FFT products are **\*not\*** intended to be the forecast, but are system indicators of potential concern. The role of the forecaster in evaluating available information is **critical**.*

# Overview of CARFFG System Products (Part 1)



**THANK YOU**