FFGS Additional Functionalities and Products

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HYDROLOGIC RESEARCH CENTER
23 May 2018
Advanced Functionalities

• 0. Multi-Model QPF
• A. Urban Flash Flood Warning
• B. Riverine Routing
• C. Landslide Occurrence Prediction
• D. Seasonal to Sub-seasonal Runoff and Flow Forecasting
# 0. Multi-Model QPF

Example from the Black Sea Middle East (BSMEFFGS)

QPF from 3 operational NWP models available to forecasters

<table>
<thead>
<tr>
<th>Forecast Products</th>
<th>ALADIN Forecast</th>
<th>ALADIN FMAP</th>
<th>ALADIN FFFT</th>
<th>IFS Forecast</th>
<th>IFS FMAP</th>
<th>IFS FFFT</th>
<th>WRF Forecast</th>
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<th>WRF FFFT</th>
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</table>
0. Multi-Model QPF

Example from the Central Asia Region (CARFFGS)
QPF from 2 operational NWP models available to forecasters

<table>
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<th>DT</th>
<th>WRF D01 Forecast</th>
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<th>WRF D01 FFET</th>
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0. Multi-Model QPF

WRF domain 01
13 km x 13 km

WRF domain 02
4 km x 4 km
A. Urban Flash Flood Warning

Gridded Precipitation Input (observations and forecasts) from FFGS

Gridded Adjusted Radar Input and other local rainfall input

Initial States from FFGS

High Resolution Soil Water Model

High res DEM and spatially-distributed data

Q/C

Urban Routing Model (surface and subsurface)

Urban infrastructure and control data

Displays

: UFFWS

: FFGS
A.1 Basic Technical Elements UFFWS

\[ \frac{\partial y}{\partial t} + \frac{\partial (vy)}{\partial x} = 2q_l/B - f \]

\[ S_f = S_0 - \frac{\partial y}{\partial x} \]
Total Rainfall Generating Inlet Capacity:
\( (N_s+N_m) \ Q_T = (1/3.6) \ U_0 f_A \ A \)

Total Storm Sewer Volume Capacity:
\( X_{S0}^0 = \sum_{k=0}^{M} (\pi D_k^2 / 4) \ L_k \)

Time to Storm Sewer Overflow:
\( T_s^0 = - (1 / b) \ln\{1 - b \ X_{S0}^0 / [(1/3.6) \ U_0 f_A \ A]\} \)

Scaling of Bankfull Q and Bankfull v:
\( Q_{BNKF} = \alpha A^\beta \)
A.2 Demonstration of Feasibility (City of Pretoria)
A.2 Demonstration of Feasibility (City of Pretoria)

Basin Areas: 1-5 km²
Rain Grid Area: 16 km²
A.2 Demonstration of Feasibility (City of Pretoria)

Av. Basin Area: 1-5 km²
Rain Grid Area: 16 km²
A.2 Demonstration of Feasibility
(City of Pretoria)
A.2 Demonstration of Feasibility (City of Pretoria)
A.3 Example Surface Drainage Flow
A.4 Use for Flood Hazard Mitigation

Application to Tegucigalpa, Honduras, for flood hazard mitigation

Only Surface Storm Drainage through Streams and Streets

Urban watersheds defined at a resolution of 0.01 km².

Street Ditches and Small Dams modelled

\[ V \approx W^* h^* e(t)^* L \]

Watershed of interest

Headwater sub-basin

Downstream sub-basin
A.5 FFGS Implementation

FFGS application to Cendere Basin, Istanbul.

Only Surface Storm Drainage through Streams and Streets

Urban watersheds defined at a resolution of 0.25 km$^2$. 
Goal:
To provide capability to forecast flow discharge at pre-specified locations along the channel network of selected river basins and to train forecasters and others on the use of information.

Prerequisites:
1. Mesoscale numerical weather prediction forecasts (single or ensemble forecasts) for FFGS ingest (*countries and the RC*).
2. Selection of a specific river basin and forecast points within the river basin (*countries and the RC*).
3. Information at sites of the river channel and reservoir information for those reservoirs included (*countries*).
B.1 Riverine Routing Sub-system

In operation, FFGS Total Channel Inflow ingest to Channel Routing Model.

**FFGS SIMULATION PERIOD**

- **FFGS**
  - Regional Gauge-Corrected Satellite-Based Precipitation Estimates (BSMEFFG System) (4km; hourly)

**FFGS FORECAST PERIOD**

- **Mesoscale NWP Model(s)** (Regional Center) (4 starts daily, 48h max lead time)

**Simulation**

- Temperature Estimates (Gauge Obs., Climatology Models) (6hourly)

**Forecast**

- Adjustment Factors
- Optional Adjust

**Channel Routing Model**

- Total Channel Inflow
- Channel Initial Conditions

**Channel Routing Model**

- Streamflow Ensemble
- Forecast Product Generation
B.2 Type of Channel Routing

Steep slopes (> 0.01-0.001)
Kinematic routing

Mild Slopes (>0.0001)
Diffusive Routing (Muskingum-Cunge)

\[
\frac{\partial Q}{\partial t} + \frac{\partial (Q^2)}{\partial x} + gA \frac{\partial h}{\partial x} - gA s + gA S = 0
\]
B.3 Type of Interface: Simulation Products
B.3 Type of Interface: Ensemble Traces and Table

PANDHM v1.0p - Panama Distributed Hydrologic Model System
Experimental Interface of the Hydrologic Research Center

2016-10-10 00:00 UTC - Streamflow Forecast Ensemble - Outlet 2024511394

Download the CSV data file: 2016101000_2024511394_streamflow_forecast_base_ensemble.csv

2016-10-10 00:00 UTC - Streamflow Forecast Ensemble - Outlet 2024511394
Unit: cm

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B.3 Type of Interface: Forecast Maps
B.4 Reservoirs and Lake Levels

Reservoir Storage/Release Module for the Routing Component

\[ R_L : \text{Watershed Inflow to Lake} \]
\[ R_R : \text{Rainfall/Inflow to Lake Surface} \]
\[ E : \text{Lake Evaporation Outflow} \]
\[ Q_s : \text{Spillway Outflow for All Spillways} \]
\[ Q_{nw} : \text{Navigation Water Supply Outflow} \]
\[ Q_{h} : \text{Hydroelectric Energy Production Outflow} \]
\[ Q_{m} : \text{Municipal and Industrial Water Supply Outflow} \]
B.5 Influence of Hydrologic Model Parameters

Hourly simulation of discharge (blue line) with *unadjusted* model parameters, compared to observations (black line) – Hourly Streamflow Observations Important for Calibration
C. Landslide prediction using FFGS output

- C.1 Susceptibility map development in a region with an adequate database (El Salvador, Central America) (completed)
- C.2 Real Time landslide prediction using FFGS rainfall and soil water thresholds in El Salvador (completed)
- C.3 Generalization for Central America and implementation/demonstration in CAFFG (on going)
- C.4 FFGS Product Console for Landslide Assessment
C.1 Susceptibility Mapping

Parameter

(e.g. Slope)

Classes

Low

Medium

High

Landslide Class

Density

\[ N_{\text{pixels}} \text{(with landslides in Parameter Class)} / N_{\text{pixels}} \text{(in Parameter Class)} \]

Landslide Map

Density

\[ \frac{\text{Total } N_{\text{pixels}} \text{(with landslide)}}{\text{Total } N_{\text{pixels}} \text{(in region)}} \]

Factor Weight for each Class

\[ W_i = \ln \left( \frac{L \cdot C \cdot D}{L \cdot C \cdot D} \right) \]

Normalized Factor Weight for each Class

\[ \bar{W}_i = \frac{W_i}{\sum W_i} \]

Total Susceptibility

Continuous Susceptibility

Weight Values to Discrete Classes

Legend

Weight Class

- Low

- Medium

- High

- Very High

Landslide Inventory Map

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C.2 Real-time Occurrence Prediction based on FFGS Rainfall and SM
C.3 Generalization for Central America
Design and Implementation Status of Current Advances

Landslide Module operational in CAFFG System

| ASML - 96 hr | 2017-07-15 12:00 UTC | REGIONAL |
| MAXP - 24 hr | 2017-07-15 12:00 UTC | REGIONAL |
| LST - 24 hr  | 2017-07-15 12:00 UTC | REGIONAL |

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D. Seasonal to Sub-seasonal Ensemble Forecasting

Seasonal Forecasting of Snowmelt and Rain Runoff

Assessment Date 1 April 2017

15-Day Runoff Total Ending 15 June 2017

Tajikistan 2017 Assessments
D.1 Seasonal to Sub-Seasonal Ensemble Runoff and Flow Prediction

Interactive Maps for Runoff Volume

Ensemble Forecast Time Series for a 84.63-km² basin (1 April 2017)

Median Runoff and River Flows (South Tajikistan)
E. Inundation Mapping for SM Estimation

MRC FLASH FLOOD GUIDANCE SYSTEM - MRCFFG
In Operation Since 2009

Development/Implementation/Training: Hydrologic Research Center
Purpose: Provide Regional Products with High Resolution to Forecasters in Thailand, Lao PDR, Cambodia and Vietnam to Provide Real-Time Warnings for Flash Floods
Sample Products for Flash Flood Prone Basins Delineated in Vietnam
(Son Tinh Typhoon Landfall in Northern Vietnam in October 2012)

Precipitation at Landfall from NESDIS HydroEstimator

Upper-Soil Water Saturation Fraction at Landfall from operational MRCFFG (uses bias-adjusted HE pixel values)
E. Inundation Mapping for SM Estimation

STANDING WATER CORRECTIONS TO MODEL SOIL WATER FROM NASA PRODUCTS

MODIS-Based Observed Inundation Area in Cambodia

MRCFFG Modeled Drying Surface Soil Water in Cambodia

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E. Inundation Mapping for SM Estimation

Method: Assimilation of saturation of upper soil in catchments with inundation greater than 85% and use of soil model to adjust lower soil water.