Real-time Global Flood Monitoring and Forecasting using an Enhanced Land Surface Model with Satellite and NWP model based Precipitation

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Global Flood Monitoring System (GFMS) is running quasi-globally (50°S-50°N) every three hours at 1/8th degree, and routing is also running at 1km resolution.
Global Flood Monitoring System (GFMS)/DRIVE model
http://flood.umd.edu

Soil, Vegetation, Snowbands (Princeton)
DEM (1km, HydroSHEDS)

12km Res. Streamflow 12km res. [m^3/s]
12km Res. Routed Runoff 12km res. [mm]

0.25°, 3-hourly TRMM + other satellites [TMPA/3B42]

15yr Retrospective simulation

Flooding at a point, if:

\[ R > P_{95} + \delta \text{ and } Q > 10 \text{ m}^3/\text{s} \]

\[ R: \text{ routed runoff (mm)}; \]
\[ P_{95}: 95^{th} \text{ percentile value of routed runoff}; \]
\[ \delta: \text{ temporal standard deviation of routed runoff}; \]
\[ Q: \text{ discharge (m}^3/\text{s}) \]
Experimental Inundation Mapping:

(1) Define a referential water coverage based on retrospective model simulation;

(2) Apply a small threshold to consider a certain water capacity of each pixel.
Example of Global to Regional Flood Detection: Recent Flooding caused by “Haiyan” Typhoon (Nov, 2013)
2 deaths
1 death

Yujiang River
Nanning

Streamflow 12km res. [m^3/s]
03Z07Nov2015

1km Surface water storage [mm]

Nanning

X

X

2 deaths
1 death

1km Inundation map [mm]

Inundation map 1km res. [mm]

Jan 2011

Jan 2012

Jan 2013

1km Inundation map [mm]

Jan 2012

Jan 2013

12km Streamflow (m^3/s)
Western Indonesia Flooding
Short term precipitation and flood forecast on Jan 2, 2014

Streamflow \[m^3/s\] at Lat: -1.3 Lon: 104.1

Satellite precipitation
NWP (GEOS-5) precipitation
For future 4~5 days
Global evaluation TMPA real-time (DRIVE-RT) and research (rain gauge adjusted, DRIVE-V7) [15yrs (1998~), 3-hrly, 1/8° res.]

(1) **Flood event** based evaluation using 2,086 archived flood events by Dartmouth Flood Observatory

(2) **Streamflow** based evaluation at 1,121 river gauges by GRDC, across the globe.

Flood event based evaluation

Flooding at a point

\[ R > P_{95} + \delta \]

and

\[ Q > 10 \text{ m}^3/\text{s} \]

- \( R \): routed runoff (mm)
- \( P_{95} \): 95th percentile value of routed runoff
- \( \delta \): temporal standard deviation of routed runoff
- \( Q \): discharge (m\(^3\)/s)

Matching floods between simulated and reported

Temporal window: ±1 days

Spatial window: all upstream basin area within ~200 km & ~100 km downstream stem river

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Flood detection verification against the Dartmouth Flood Observatory (DFO) flood database with 2,086 flood events during 2001-2011, over the TRMM domain.

Probability of Detection (POD):
DRIVE-V7: 1,820 (87.2%)
DRIVE-RT: 1,799 (86.2%)

2086 reported events over TRMM domain
Flood detection verification against the Dartmouth Flood Observatory (DFO) flood database over the 38 Well Reported Areas (WRAs) for floods with duration more than 3 days.

Bottom line--For 3-day floods in basins with few dams using RT rainfall:

$POD \sim 0.9 \quad FAR \sim 0.7$
Comparison with 1,121 GRDC Streamflow Gauges-Nash-Sutcliffe (NSC)

Daily: 32% of gauges with positive values with mean of 0.22
Monthly: 60% of gauges with positive values with mean of 0.39
Distribution of the number of gauges with positive monthly and daily NSC metrics for DRIVE-V7 and DRIVE-RT simulation for 2001-2011, respectively.
Real-time Evaluation of on-line events
41% (12) out of 29 gauges with daily NSC>0 with mean of 0.23

Internet source: April 19, 2013, Des Plaines, IL

USGS/NOAA WaterWatch program http://waterwatch.usgs.gov
Discharge (USGS05454500)

Mean Annual Precipitation

Daily Precip. PDF

(IFC radar, NuWRF...)

Precipitation
Evaportranspiration
Soil moisture
SWE
SS/Inundation
Summary and Future

1. A new version of the Global Flood Monitoring System (GFMS) has been implemented for real-time application using the U. of Washington VIC community Land Surface Model and a new physically based DRTR routing model from the U. of Maryland for more accurate flood calculation and greater flexibility, including 1 km routing. The VIC/DRTR combination is called the Dominant river Routing Integrated with VIC Environment (DRIVE) system.

2. The evaluation of the DRIVE model shows promising performance in retrospective runs vs. observed streamflow records and in flood event detection against global flood event statistics. Results show impact of dams (higher FAR), potential improvement with improved accuracy of satellite precipitation and greater skill with longer floods.

3. High resolution (1 km) routing and water storage calculations will lead to high resolution inundation mapping for comparison with high resolution visible and SAR imagery of floods.

4. For the future we will also:
   - be implementing a “dam module” to try to include the impact of man-made structures on the calculations
   - be evaluating the use of alternative satellite precipitation products and forecast precipitation info. from numerical models (adjusted by the satellite estimates).
Thanks!