WEATHER CLIMATE WATER
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Advances in Flash Flood Guidance System

WMO OMM

World Meteorological Organization
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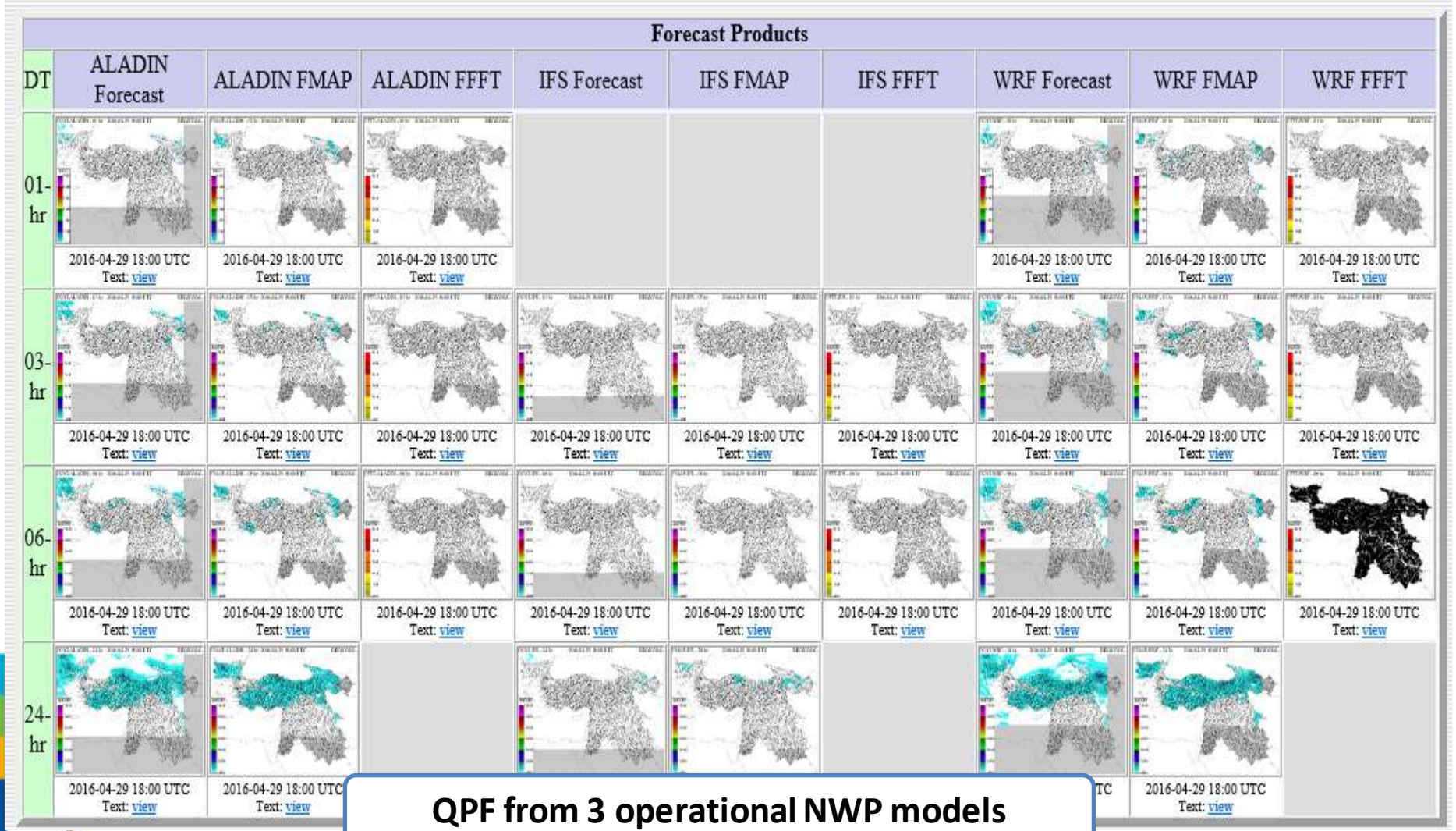
Advances in FFGS

The following enhancements are in various stages of development and implementation based on specific country needs, expressed interest, funding priorities and cooperation:

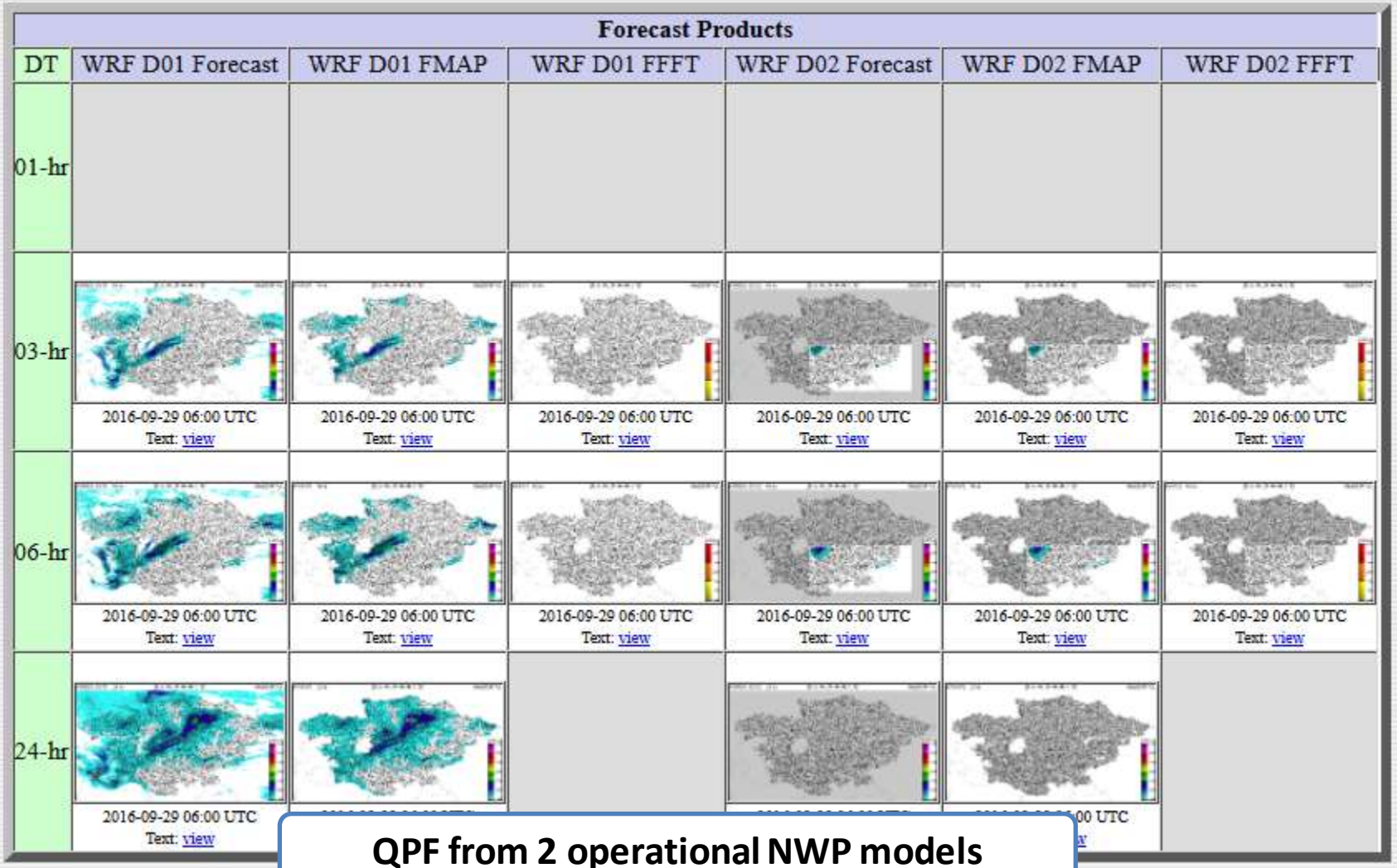
- **Multi-model Quantitative Precipitation Forecast (QPF) use within FFG systems**
- **Use of satellite inundation mapping and associated surface soil moisture observations to adjust FFGS soil water estimation**
- **Landslide susceptibility and landslide occurrence prediction**
- **Urban Flash Flood Warning**
- **Riverine routing and discharge ensemble prediction**

Multi-model Quantitative Precipitation Forecast (QPF) – BSMEFFGS



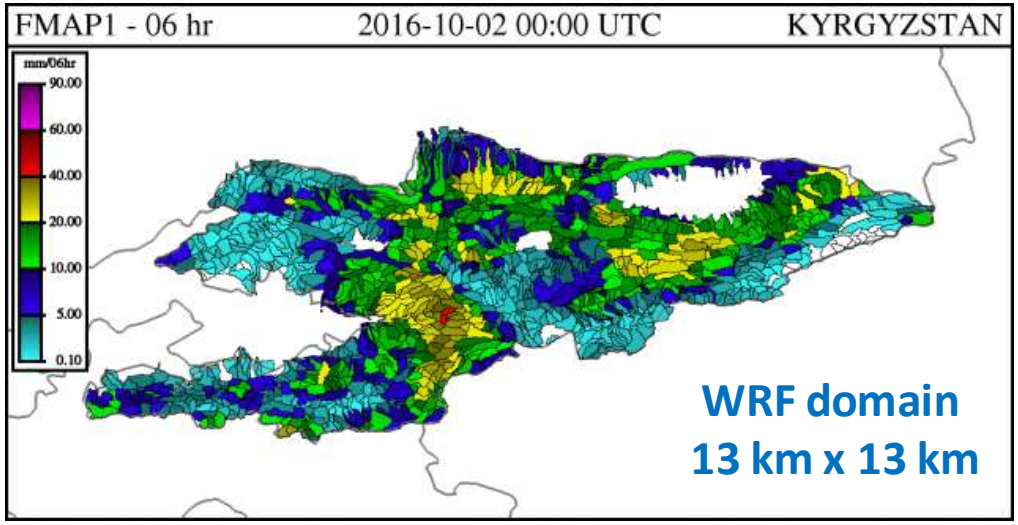
QPF from 3 operational NWP models

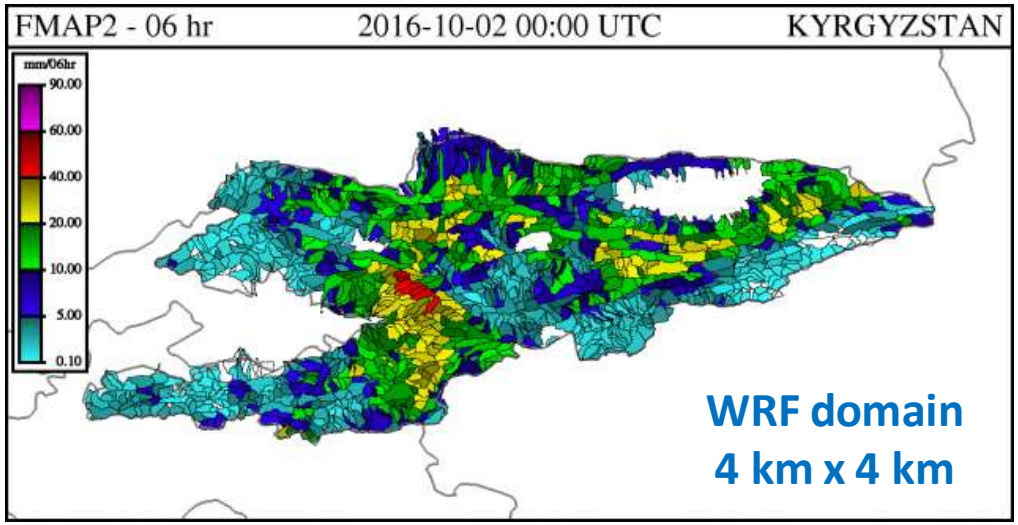
Multi-model Quantitative Precipitation Forecast (QPF) – CARFFGS



QPF from 2 operational NWP models

Multi-model Quantitative Precipitation Forecast (QPF) – CARFFGS

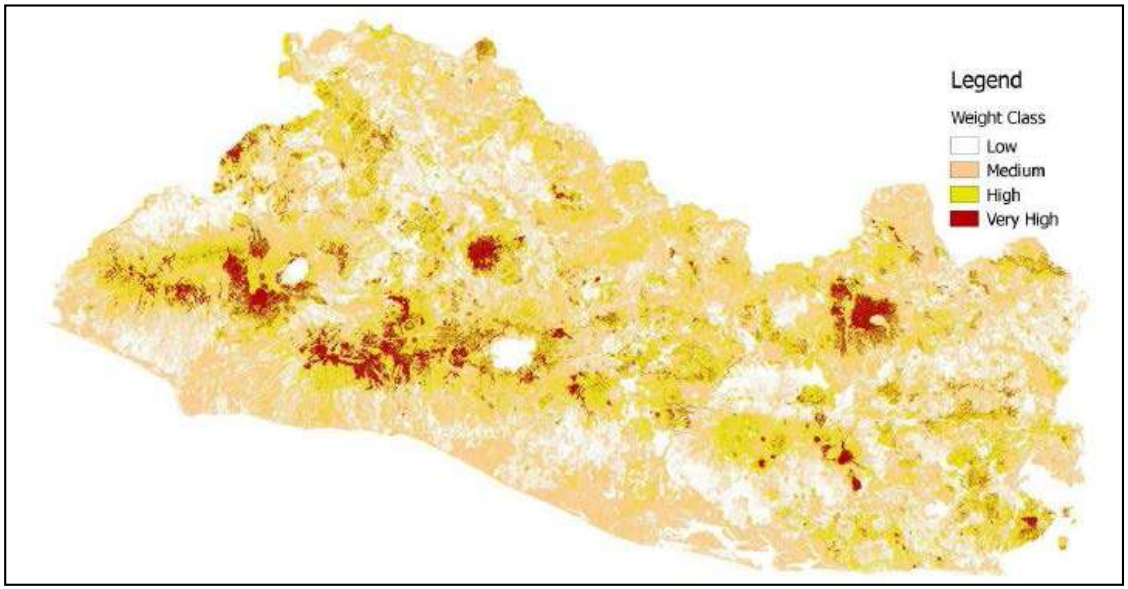




Landslide Susceptibility

- Demonstration project for landslide early warning began in 2012 with pilot project in Central America.

- First step relates susceptibility to landslides to physical characteristics of land surface for historical landslide events with high resolution data. The relationship is then extended to entire country/region.



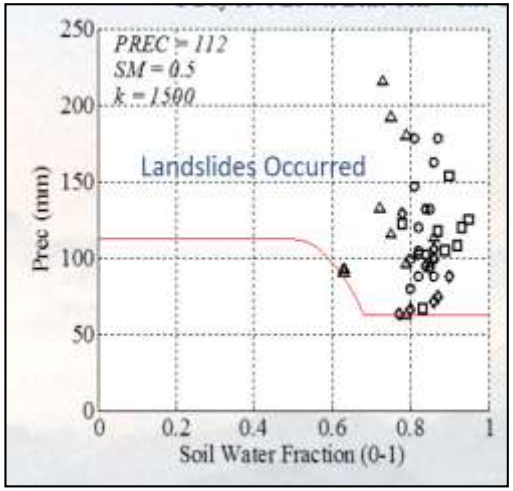
Example Susceptibility map with 30-m resolution El Salvador as part of the Central America FFG System.
Susceptibility categories of low, medium, high and very high.
Results from El Salvador then used throughout Central America.

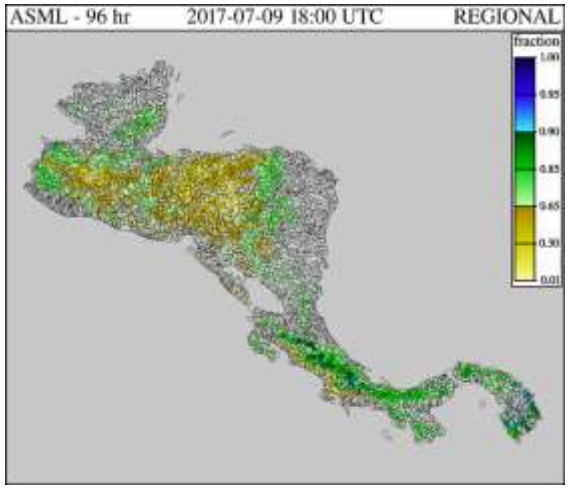
Landslide Susceptibility

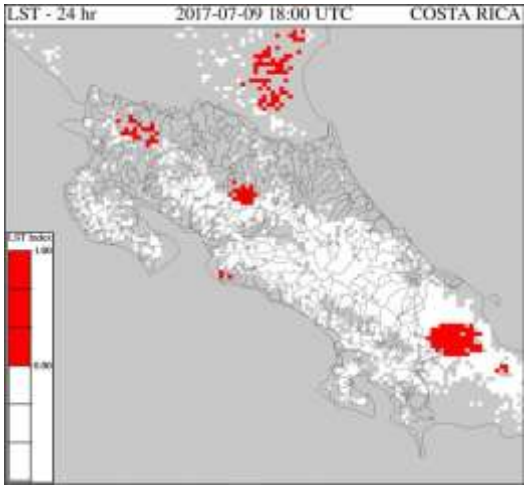
1) From database of historical landslide events, develop threshold conditions of antecedent soil moisture condition and precipitation for those known events.

2) Use of real-time FFG system estimates of lower soil moisture and precipitation to identify at-risk watersheds.

3) And then the landslide susceptibility map to identify critical regions within watersheds.







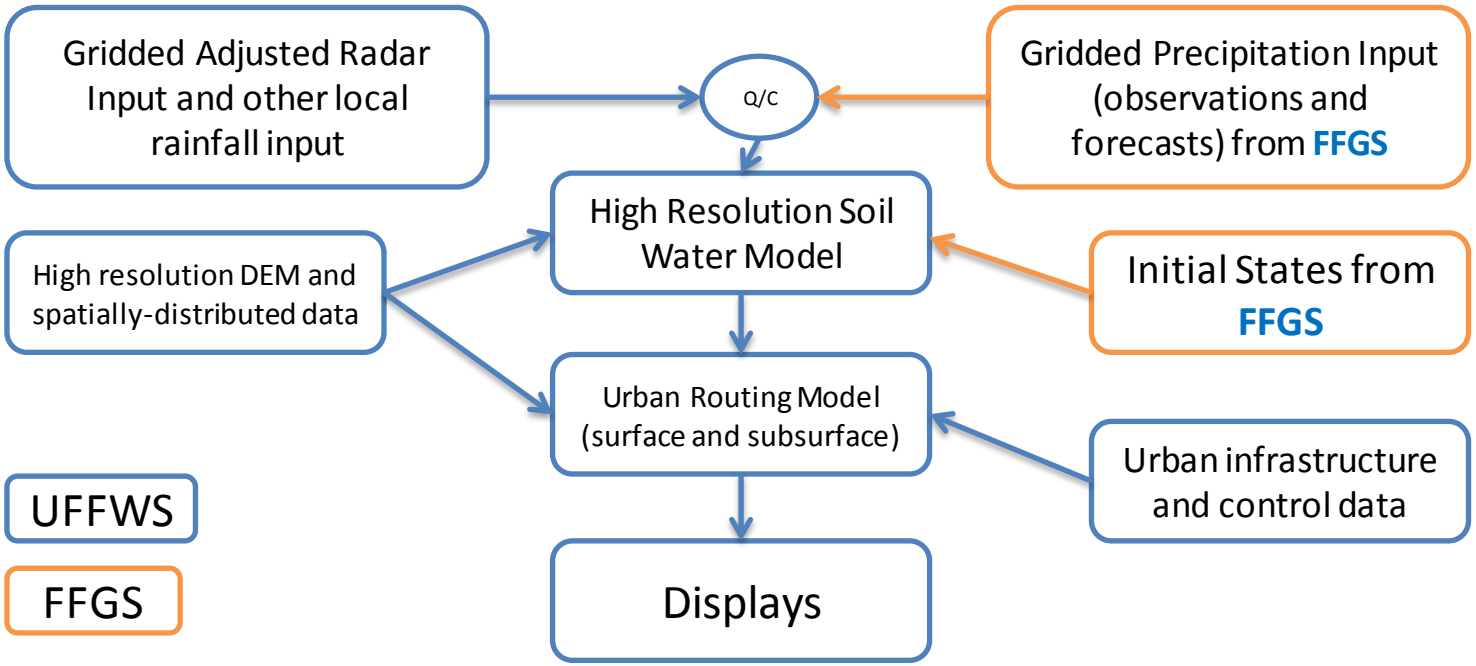
Landslide Susceptibility

- The Central America Landslide early warning capabilities implemented within the Central America FFG System in 2016.
- There are discussion of extending to South Asia, Southeastern Asia and Oceania, and others.
- Historical analysis is data-intensive, requiring quality records of landslide occurrence, location and other attributes.

Urban Flash Flood Warning

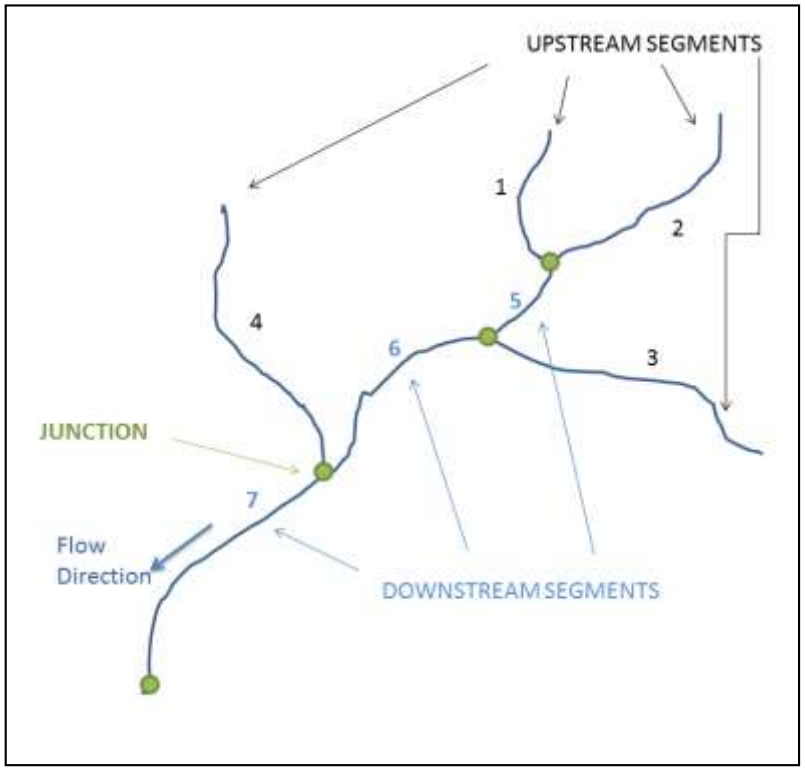
- Currently 50% of the worlds population lives in the urban environment. This is expected to increase to 70% by 2050.

- Builds upon data available from FFGS (precipitation, model conditions) and includes high resolution modeling in urban area to include both surface and subsurface flow routing.



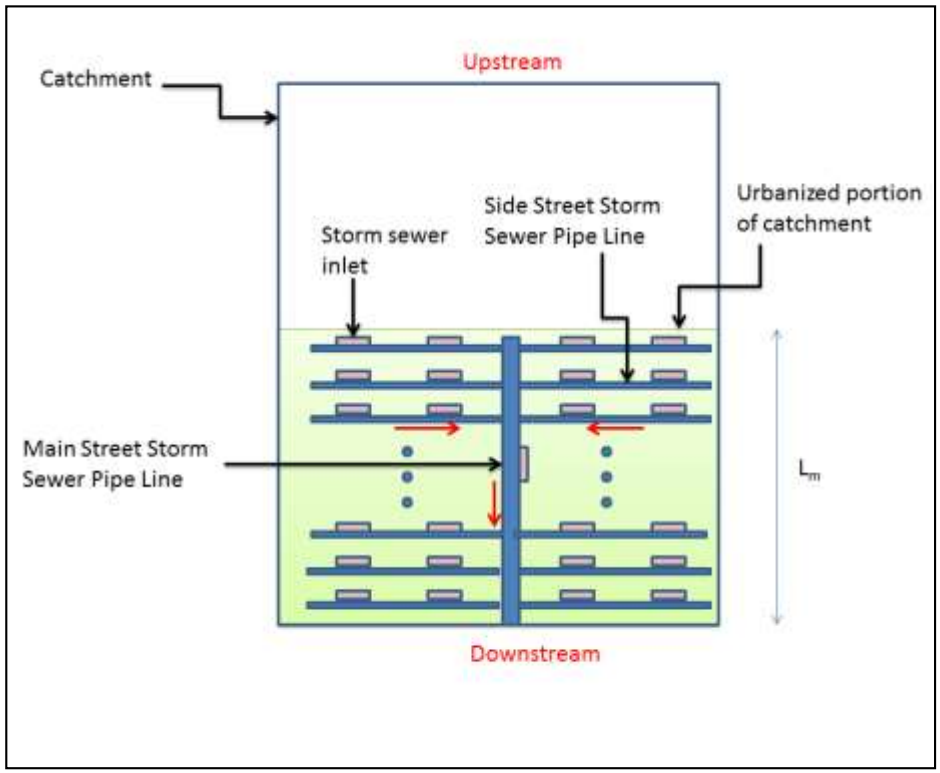
Urban Flash Flood Warning Basic Elements

Natural or modified surface drainage



Requires information on stream or canal network, capacity, and control structures.

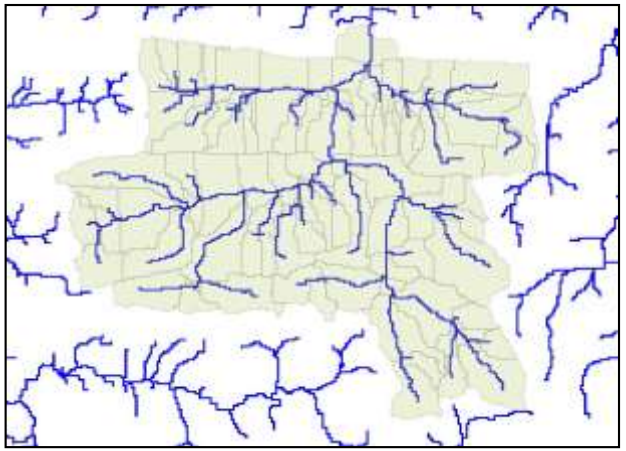
Sub-surface drainage

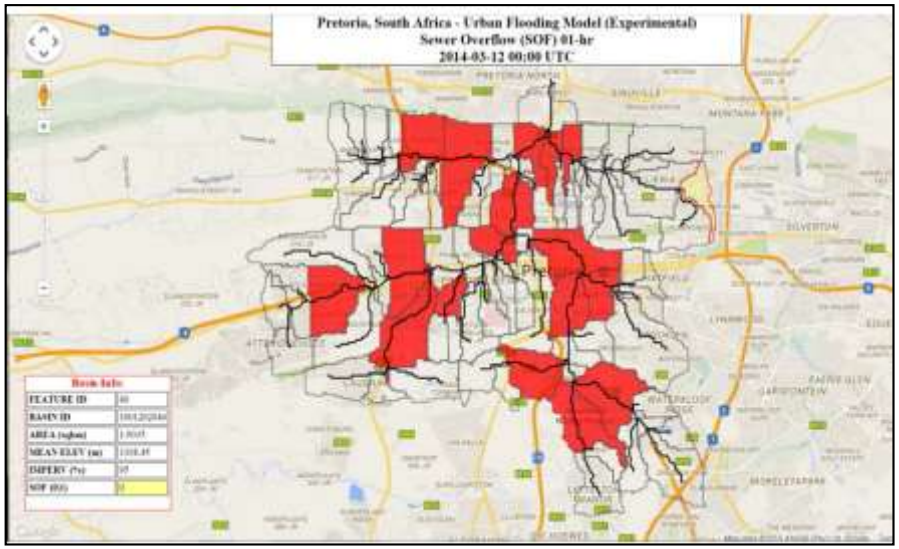


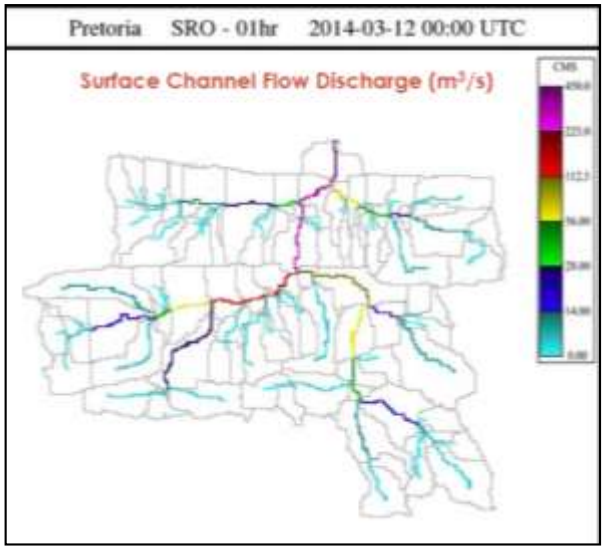
Requires information on storm sewer network, including number of inlets, inlet capacity, storm sewer capacity, and control.

Urban Flash Flood Warning (Pretoria)

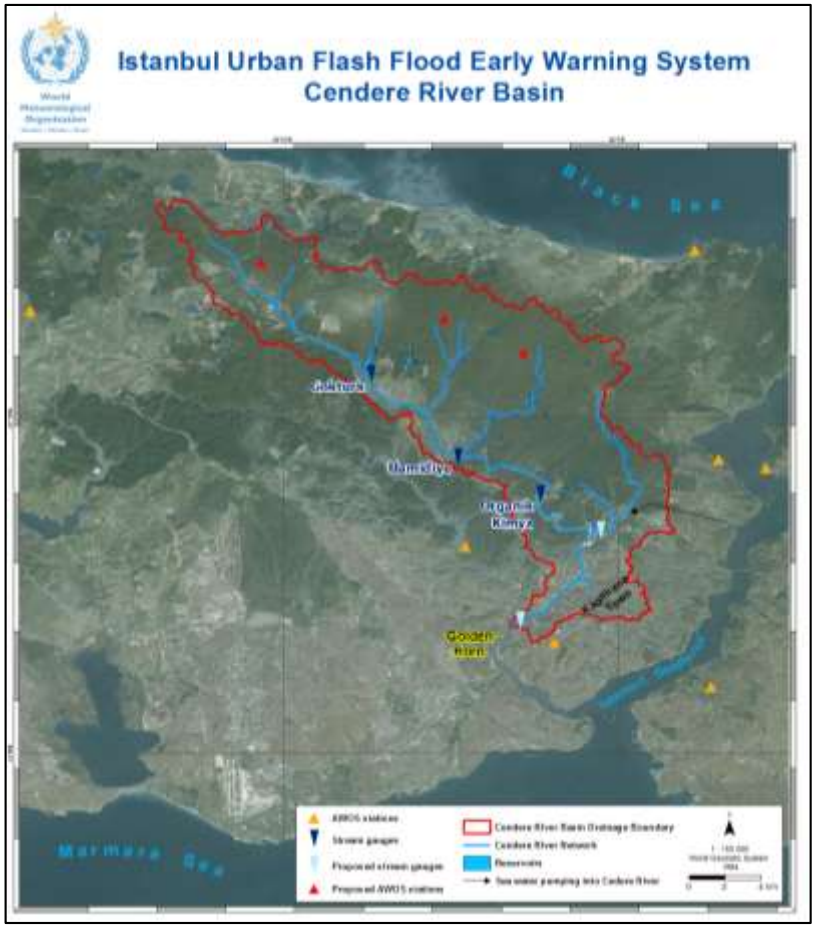
- Used storm sewer network diagram to define sub-surface network.
- Surface and subsurface flow modeled.
- Urban watersheds define at a resolution of 2 km^2.
- Red watersheds indicate where system indicates storm sewer overflow.

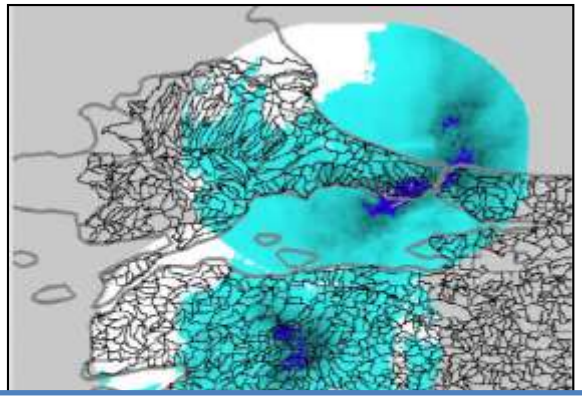




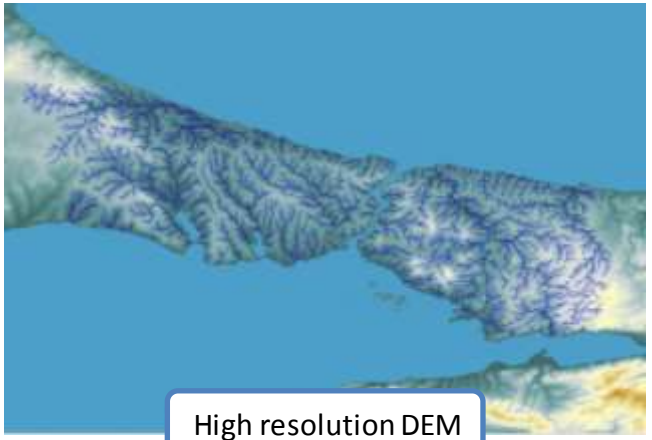


Urban Flash Flood Warning (Istanbul)





Gauge-corrected radar-rainfall products from FFGS on Regional FFGS drainage basins
(FFGS operational at TSMS, Ankara)



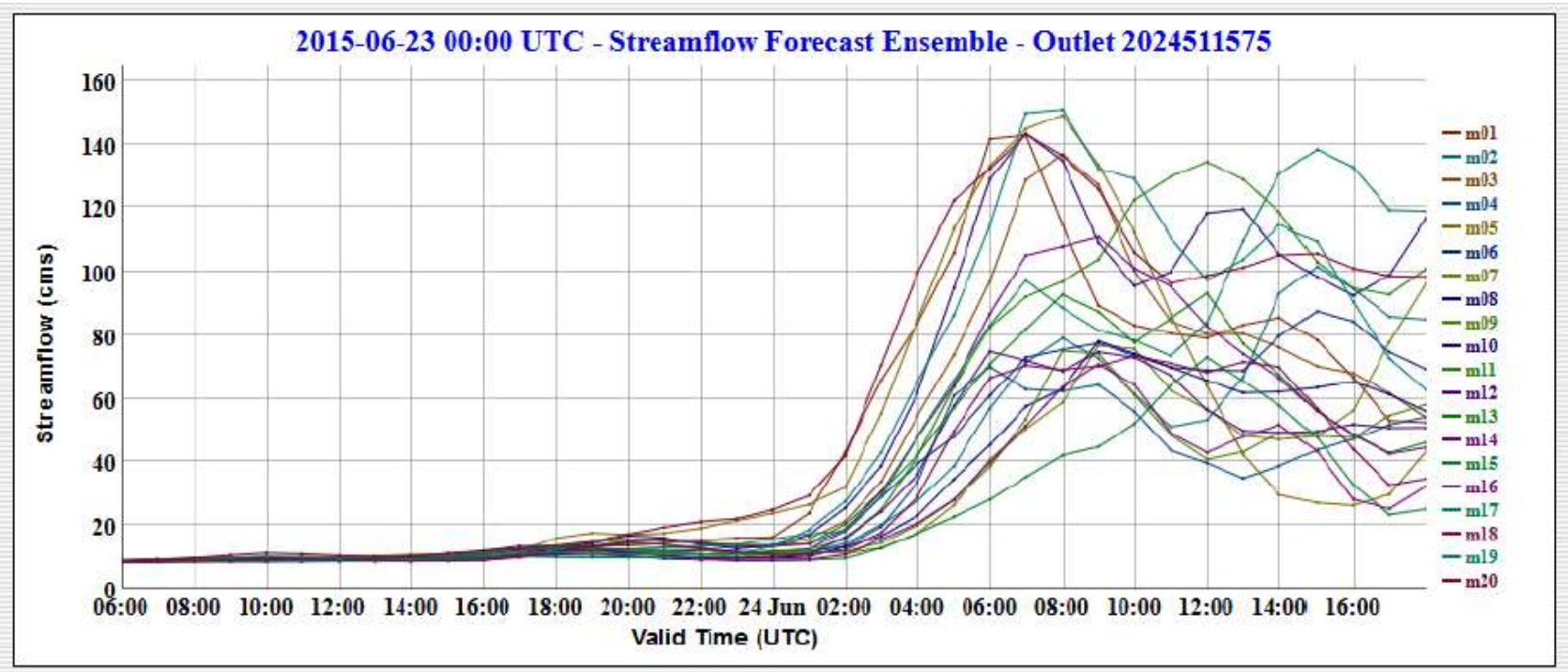
High resolution DEM

Riverine Routing and Ensemble Discharge Prediction

- Extracts sub-catchment runoff from FFG System and routes river flow through channel network at high resolution to estimate discharges.
- Algorithms developed to consider operation of large reservoirs (requires information on operating curves).

Riverine Routing and Ensemble Discharge Prediction

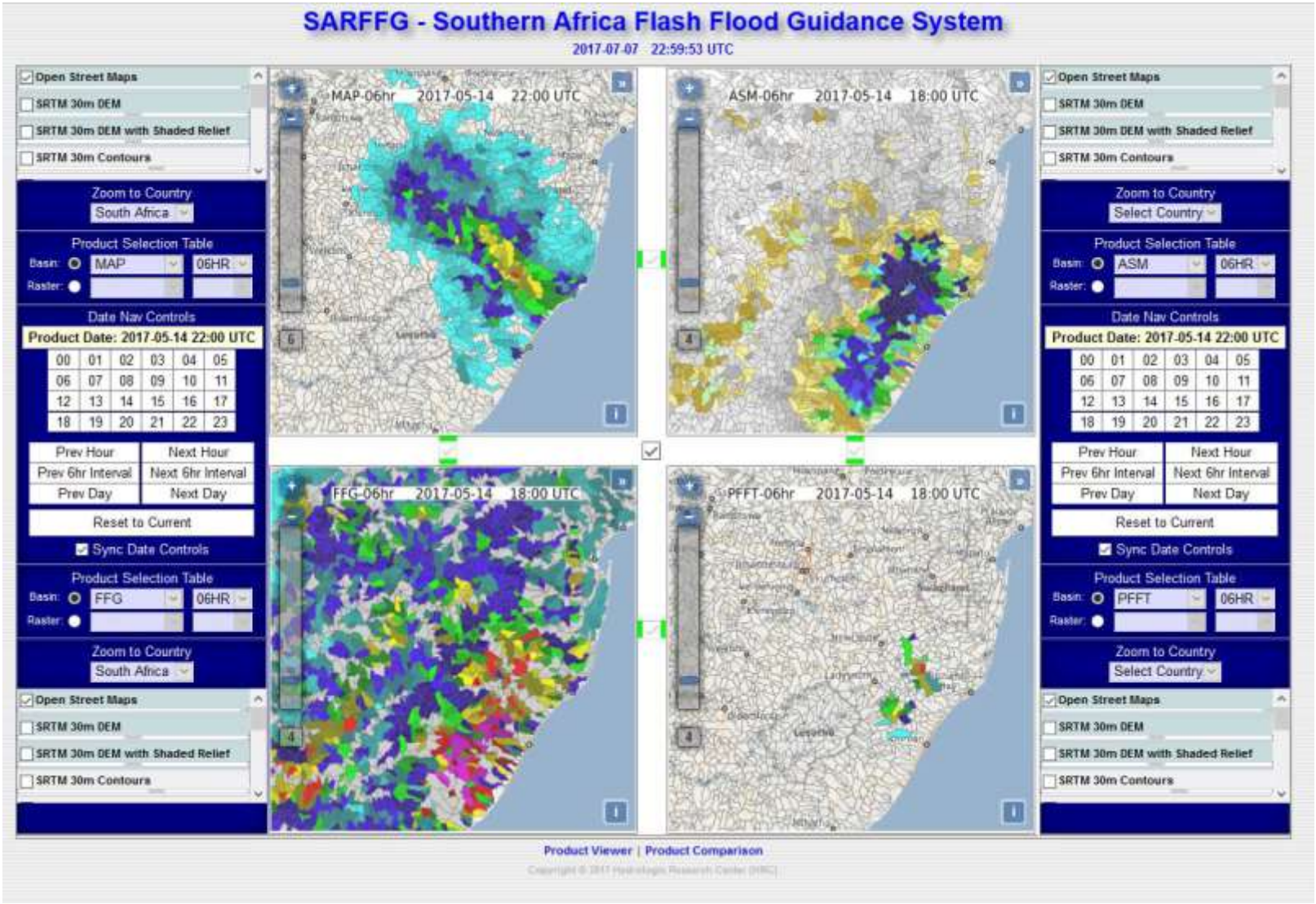
- Ensemble discharge prediction if multiple NWP predictions or ensemble NWP results from single model are available.
- Longer lead time of NWP predictions is required (> 48hours).
- Bias adjustment on forecast precipitation will also be required.



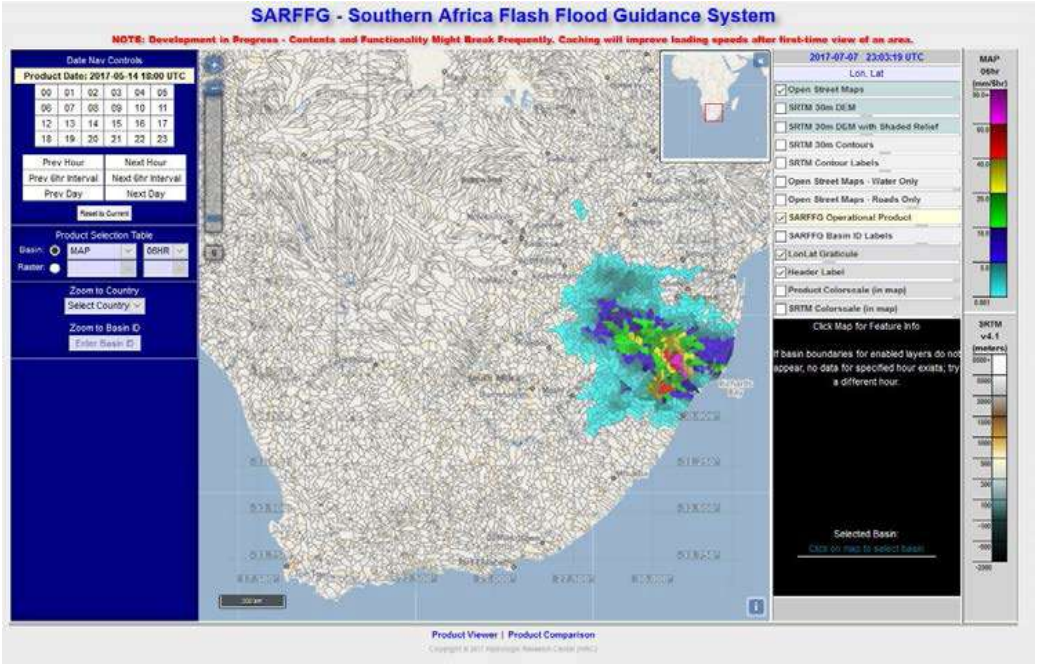
Riverine Routing and Ensemble Discharge Prediction

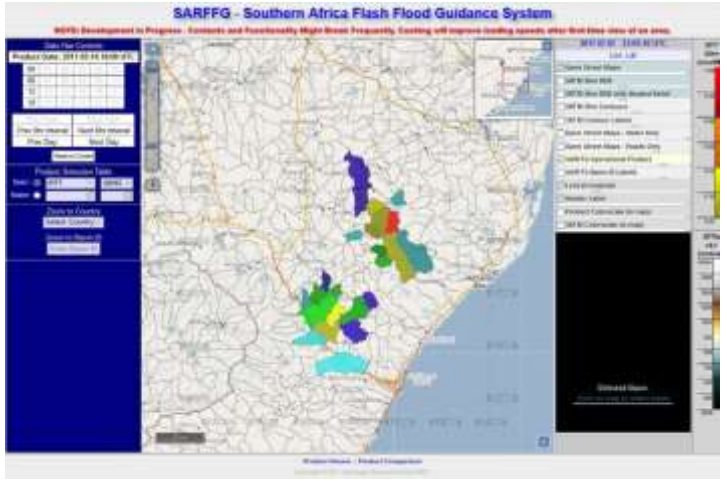
Harsit River basin, Turkey

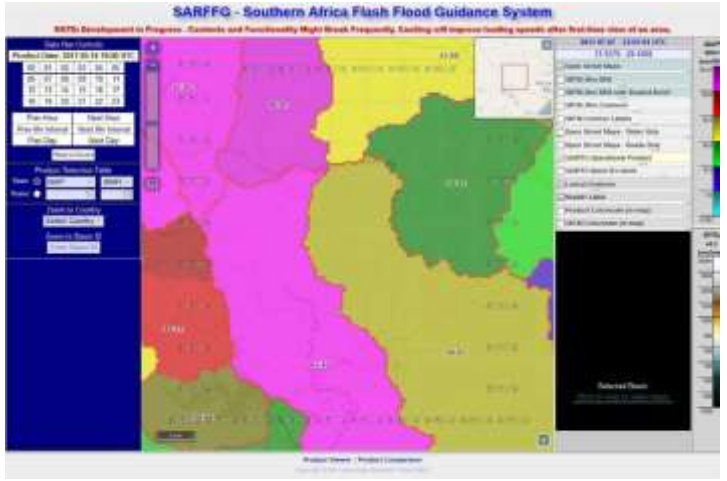
MapServer-based Forecaster Interface



MapServer-based Forecaster Interface







Thank you

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For more information please visit:	**http://www.wmo.int/ffgs**
	http://www.hrcwater.org

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