RECENT HYDROLOGIC APPLICATIONS
USING REMOTELY SENSED AND
ENVIRONMENTAL DATA
AND GEOGRAPHIC INFORMATION SYSTEMS

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Hydrologic Research Center
http://www.hrc-lab.org
Advancing the science and engineering of hydrology and water resources.
Outline of Laboratory Session

Presentation of Recent Applications

• **PANMAP** – rainfall estimation and forecasting for the Panama Canal watershed

• **HRCDHM** – distributed hydrologic modeling for streamflow forecasting

• **CAFFG** – flash flood guidance for Central America

• **INFORM** – use of climate information in reservoir management

“Hands-on” Demonstration of PANMAP processing
Introduction to PANMAP

GOAL:

- To design and implement a forecasting system for real-time rainfall forecasting over the Panama Canal Watershed

- Produces hourly precipitation estimates and forecasts for subcatchments of 150-400km² with a maximum forecast lead time of 12 hours.

- Development began in 1997, implemented in Oct 1998 Under operational use at the Panama Canal Authority
Need for Forecasting

Operation of the Panama Canal

• 13,000 – 14,000 vessels traverse the Panama Canal each year

• System of locks raise ships from sea level to level of Lake Gatun (26 m above sea level) between Pacific and Atlantic Oceans

• Objectives of forecasting is to maintain level of Lake Gatun
Panama Rain Storm
Panama Canal Watershed

3200km² of mountainous terrain

Divided into 11 subcatchments ranging in size from 150-400 km²

Subcatchment 11 is Lake Gatun
PANMAP Data Sources

**Radar** – 10cm weather radar located in Panama City

**ALERT gauge** – approx. 25 automated hydromet stations located throughout watershed

**Radiosondes** – upper air information from radiosondes launched twice daily

**ETA model** – operational mesoscale prediction produce by NOAA

**Digital terrain elevation data** – used in surface winds analysis
PANMAP – current status and verification

System used operationally since October 1998 at PCA

Validation performed for events through December 2001

(Georgakakos and Sperfslage, 2003. Preprints of AMS Annual Meeting 2003, paper J4.10)

Introduction to HRCDHM

Hydrologic Research Center Distributed Hydrologic Model

• Developed as research tool to explore use of distributed hydrologic model in operational flow forecasting

• Uses spatially distributed precipitation input from operational WSR-88D weather radar

• Hydrologic model components for mean areal precipitation computation, runoff-generation and streamflow routing

• Allows for spatially distributed parametric input

• Sponsored by NWS Office of Hydrologic Development
1. Watershed Delineation

Based on GIS processing of digital terrain data

Provides subcatchment geometric characteristics (A, L, S) used in hydrologic model components
Major Components of HRCDHM software

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   Based on GIS processing of digital terrain data

2. Radar Data Processing
   Ingest of raw (binary) radar files and subbasin MAP computation
Major Components of HRCDHM software

1. Watershed Delineation
   Based on GIS processing of digital terrain data

2. Radar Data Processing
   Ingest of raw (binary) radar files and subbasin MAP computation

3. Hydrologic Modeling
   Model components based on those used operationally in the U.S.; produces streamflow estimate at outlet of each subcatchment

Hours beginning 11/13/1993

FLOW (CMS)

0 200 400 600 800
0 24 48 72 96 120 144 168
HRCDHM

GIS-processed small-scale basins
User-defined aggregation level
Binary radar files

Watershed Processing

Radar Processing

Subcatchment definition

Subcatchment MAP

Hydrologic Modeling

subcatchment runoff
soil moisture
streamflow
HRCDHM Interface

** 1. RADAR DATA PRE-PROCESSING **

PLEASE CHOOSE FROM THE FOLLOWING ACTIONS:

1. Specify processing start date [Current: 07/01/96].
2. Specify number of days to process [Current: 18651].
3. Specify processing resolution [Current: 225.9 sqkm].
4. Import NEXRAD radar data to average precip indices.
5. Execute the distributed model.
6. Exit to MAIN MENU.
7. Exit program.

Please enter number corresponding to action here -->

** 3. DISTRIBUTED MODEL PROCESSING **

PLEASE CHOOSE FROM THE FOLLOWING ACTIONS:

1. Specify processing start date [Current: 07/01/96].
2. Specify number of days to process [Current: 18651].
3. Specify processing resolution [Current: 225.9 sqkm].
4. Import NEXRAD radar data to average precip indices.
5. Execute the distributed model.
6. Exit to MAIN MENU.
7. Exit program.

Please enter number corresponding to action here -->
Current Research on Distributed Modeling

What is the impact of input uncertainty on flow simulations from distributed model design for operational flow-forecasting?

• Examined sensitivity of flow simulations to uncertainty in both radar precipitation input and parametric input through ensemble simulations with HRCDHM

• Incorporated additional spatial database of soils properties to define distribution of hydrologic model parameters.

• Application basins were NWS-DMIP case study watersheds:
  Elk River at Tiff City, MO
  Baron Fork at Eldon, OK
  Blue River at Blue, OK
  Illinois River at Watts, OK
  Illinois River at Tahlequah, OK
## STATSGO Soils Database

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Use GIS to determine fraction of each subcatchment covered by different STATSGO map units.

Compute average and range of soil properties given in STATSGO database for each subcatchment on the soil zones consistent with hydrologic model.

Use subcatchment average soil properties to distribute subcatchment soil parameters & range to define uncertainty bounds.
Sensitivity Analysis Output

SOIL & PRECIP/UNIFORM RUN: EVENT #12
UNGAGED BASIN, A=356 km²

\[ Q_{\text{max}} = 40.1 \text{ cms} \]
\[ T_{Q_{\text{max}}} = 73 \text{ hr} \]
\[ R_{O_{\text{max}}} = 1.2 \]
\[ R_{O}(Q_{\text{max}}) = 0.83 \]
\[ T_{R_{O_{\text{max}}}} = 69 \text{ hr} \]

FLOW (cms)

0  50  100  150  200
\[ 0 \]
\[ 24 \]
\[ 48 \]
\[ 72 \]
\[ 96 \]
\[ 120 \]
\[ 144 \]
\[ 168 \]
\[ 192 \]

HOURS

TIFF CITY BASIN, A=2230 km²

\[ Q_{\text{max}} = 155 \text{ cms} \]
\[ T_{Q_{\text{max}}} = 88 \text{ hr} \]
\[ R_{O_{\text{max}}} = 0.6 \]
\[ R_{O}(Q_{\text{max}}) = 0.33 \]
\[ T_{R_{O_{\text{max}}}} = 80 \text{ hr} \]
GOAL:

• To design and implement a prototype system for computing flash flood guidance and identify regions where precipitation exceeds guidance values in real time.

• Real-time precipitation from satellite estimates in conjunction with automated gauges (DCP).

• Spatial Resolution of 100 – 300 km².

• Project began “in earnest” in late 2002; scheduled delivery: Fall 2003.
FROM FLASH FLOOD GUIDANCE TO FLOOD WARNINGS
7 Countries in Central America

#1 Challenge = Communication!

National Meteorologic Service
National Hydrologic Services
Various Response Agencies
Regional Hydrology Center
Hydro-electric Utilities
INITIATIVE COMPONENTS

• Technical System for Flash Flood Guidance Generation

• Links to Remotely Sensed and On Site Data

• System Products Dissemination

• Training and Cooperation Activities with Users
**PRECIPITATION INPUT**

**Satellite Data (NESDIS-NOAA):**
Based on GOES-12 10.7 micron channel (InfraRed)
Spatial resolution of rainfall estimates: 4 km
Duration of rainfall estimates: 1, 3, 6, 12, and 24-hour accumulations, updated hourly

**Raingauge Data:**
Automated (DCP) continuous recording raingauges
Hourly temporal resolution of rainfall accumulations
Sparse spatial coverage (< 150 in region)

**Radar Data:**
Currently in Panama only
Hourly temporal resolution of rainfall accumulations
Spatial resolution of rainfall estimates: 4 km
Definition of Catchment Units

- Spatial scale of 100 – 300 km²
- GIS-delineation processing
- GTOPO DEM (1-km resolution)
- Evaluation of stream delineation using DCW Data (1:1,000,000-Scale) and local resources
CURRENT STATUS OF TECHNICAL SYSTEM

- Satellite image and data files for 2002 - current
- Decoding and geo-referencing data files
ADDITIONAL GIS RESOURCES

Digitized Catchment Boundaries

Digitized Stream Locations

Soils Maps and Information

Land Use Maps

Land Cover/Vegetation Maps

Flood Inundation Maps

Population Data
Regional Center ➔ National Met/Hyd Services ➔ Emergency Response

Via Internet/FTP
Existing service range from modem to ISDN, and **56k** to **512k** (soon)

**Products:**
- text files, images, GIS databases
- FFG, MAP and soil moisture
- 1-, 3-, 6-, and 12-hour accumulations
- 100-300km² basins
GOAL:

• Assess benefits of the use of climate information and forecasts in operational reservoir management and planning

• Involves downscaling of GCM information, ensemble hydrologic forecasting and reservoir modeling

• Builds on results for Folsom Reservoir in California

• Sponsored by NOAA Office of Global Program, California Energy Commission and NWS
Use of Climate Information

- Daily Observed MAP > 1 mm/day
- Monthly-Average Basin MAP (mm/day)
- GCM Precipitation (mm/day)

CGCM1: $y = 3.97 - 0.0980x$, $R = 0.0977$
ECHAM3(20): $y = 1.96 + 0.1428x$, $R = 0.1834$

Lake Lanier
Management Benefits Shown for Folsom Reservoir, CA

[Bar charts showing SPILLAGE, DAMAGE, and ENERGY for Operational, Baseline, CGCM1, Echam, and Perfect scenarios.]
INFORM DEMONSTRATION SITES

Major Reservoirs in Northern California

- Trinity Dam on Trinity River
- Shasta Dam on Pit River
- Lake Oroville on Feather River
- Folsom Lake on American River
GIS in INFORM

watershed definition
elevation zones
soils characteristics
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PANMAP DEMONSTRATION