Introduction of H08 a Water Resources Model and Application

Submitted by: King Mongkut’s University of Technology Thonburi (KMUTT)
Introduction of H08 a water resources model and Application

Chaiwat Ekkawatpanit
King Mongkut’s University of Technology Thonburi, Thailand

Naota Hanasaki
National Institutes for Environmental Studies, Japan

Outline

• Introduction of H08 model

• An example of H08 model simulation in the Upper Chao Phraya River basin
  Simulation without reservoir operation
  Modeling reservoir operation
  Simulation with reservoir operation

• Application with Climate change simulation
H08 model

- H08 model
  1. Simulate both natural water cycle and human water activities at daily basis
  2. Open source software (Fortran on Linux)

Hanasaki et al., 2006, J. of Hydrol.
Hanasaki et al., 2008a, b, Hydrol. Earth Sys. Sci.
Hanasaki et al., 2010, J. of Hydrol.

Schematic of H08’s land surface process module

\[
\Delta \text{SoilMoist} + \Delta \text{SWE} = \text{Pr cp} - \text{Evap} - Q_{tot}
\]

\[
\text{SW}_{down} + \text{LW}_{down} = \text{SW}_{up} + \text{LW}_{up} - Q_h - Q_{le} - Q_g
\]
Schematic of H08’s river module

\[ \Delta \text{RivSto} = (\text{RivInf} + Q_{\text{recess}} x A - \text{RivOut}) \Delta t \]

Study Area:
Chao Phraya River Basin

<table>
<thead>
<tr>
<th>Area</th>
<th>158,000km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of Floodplain</td>
<td>35,000 km</td>
</tr>
<tr>
<td>River bed slope</td>
<td>1/50,000 ~ 60,000 (Ayutthaya – River Mouth)</td>
</tr>
<tr>
<td>Largest Discharge At C2</td>
<td>5,960 m³/s in 2006 (4,686 m³/s on Oct. 14, 2011)</td>
</tr>
</tbody>
</table>

Study Area

• In this study, we focused on Bhumibol and Sirikit Reservoirs only.
• In reality, reservoir operations are very complex.
• We propose an idealized simple reservoir model.
• Although simple, this simulation offers good insight into river management and planning.

Overall perspective

• Objective
  – Hydrological analysis of the upper Chao Phraya River basin (upper Nakhon Sawan, C2 station)
  – 1981-2004
  – Reservoir operation options

Grided data (5 min lon/lat) Hydrological model with reservoir operation Long term analysis (>1yr, monthly/annual interval)

Meteorological data

H08 model (NIES & UT)

River discharge

Reservoir storage

Reservoir release

Flooded area

Geographical data
Data development

- To execute H08, 7 meteorological variables are indispensable at daily interval, namely air temperature, humidity, air pressure, wind speed, shortwave radiation, longwave radiation, and precipitation.
- All data must be gridded at 5 min lon/lat (approx. 9km x 9km)

### Developed Data

<table>
<thead>
<tr>
<th>Data name</th>
<th>Period</th>
<th>Variables</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>K10</td>
<td>1981-2004</td>
<td>All</td>
<td>Global data</td>
</tr>
</tbody>
</table>

H08 Validation

Y6

Y6 Monthly Discharge vs Observed in mm/mo
**H08 Validation**

**W4A**

W4A Monthly Discharge vs Observed in mm/mo

**Modeling Bhumibol Reservoir**

- **High water level**: 13.462x10^9 m^3 (100%)
- **Old upper curve**: 10.8x10^9 m^3 (80%)
- **New upper curve**: 9.0x10^9 m^3 (67%)
- **2012 Upper curve**: 6.0x10^9 m^3 (45%)
- **Minimum storage**: 3.8x10^9 m^3 (28%)

Operation rule:
- Storage
- Release

End of April – End of July

Rainfall in 2011 (mm/day)
Modeling Sirikit Reservoir

- **High water level**: $9.51 \times 10^9$ m$^3$ (100%)
- **Old upper curve**: $7.2 \times 10^9$ m$^3$ (75%)
- **New upper curve**: $6.2 \times 10^9$ m$^3$ (65%)
- **2012 upper curve**: $4.3 \times 10^9$ m$^3$ (45%)
- **Minimum storage**: $2.85 \times 10^9$ m$^3$ (30%)

Long-term simulation with reservoir (Validating reservoir operation model)

- Monthly discharge at C2 [m$^3$/s] (reservoir operation included)

Succeeded in developing hydrological model with reservoir operation.
Application of H08 model

- Real time simulation
- Telemetry
- Numerical weather prediction
- Real time reanalysis
- Climate change
- Climate scenarios
- Flood protection
- Flooded area
- i-RIC model?
- River discharge
- Reservoir storage
- Reservoir release
- Irrigation requirement
- Water resources management

Meteorological data
Geographical data
New reservoir?
New reservoir operation
River planning
Reservoir management

Impact of Climate Change
MIROC-CMIP3
A2 (2070-2099)
Change temperature, precipitation, downward longwave radiation
Summary

• An integrated global water resources model (H08) was developed consisting of six modules. (natural water cycle and human water activities).

• H08 is open source software (Fortran on linux).