Open House 2007
Institute of Industrial Science
University of Tokyo

Oki and Kanae Laboratory
(Hydrology and Water Resources Engineering)

Flood Today,
and the Water Scarcity
on the Day After Tomorrow
Welcome to Oki and Kanae Laboratory!

Oki and Kanae Laboratory is always seeking for better scientific understanding of water cycle and water resources and trying to deliver it to the society. By using various tools of natural and social sciences, we are struggling with many problems on different scales from global to micro. Our laboratory consists of 31 members led by Prof. Taikan Oki and Associate Prof. Shinjiro Kanae.

What is Hydrology?

In a word, Hydrology is a study of terrestrial water cycle. To estimate the flux and storage amount of water is an essential problem and also an ultimate goal of hydrology. Left figure shows our latest estimate of it (Oki and Kanae, 2006, Science). It represents not only natural water cycle components such as precipitation but anthropogenic water cycle components such as irrigation water intake from river. Human impact on water cycle has been getting heavier, and it became a hot topic of hydrology.

Overview of Open House 2007

Theme 1 Flood

In Japan, river levee and dams have been well established up to today. However, only such hard measures never fully secure our life. In the world, a large number of people live along rivers without levee. Hydrologists should consider soft measures such as early flood warning system.

Real-time simulations

◆Weather forecast to flood forecast
◆Monitoring rainfall from the space

Flood in Thailand

◆Lessons by flood disaster in 2006
◆A pilot water management system

Flood in Japan

◆Heat island increases torrential rainfall?
◆Flood risk mapping all over Japan

Theme 2 Water Scarcity

According to the 4th report of IPCC, by the end of this century, global average air temperature will increase by 6.4 degrees at most. How will global warming affect the water resources? To give more reliable answer to this question, we are developing an evaluation tool of water demand/supply.

Impact of climate change

◆4 billion people will be under water stress
◆Heavily snowfall and global warming

Integrated water resources model

◆Natural and anthropogenic water cycle
◆Optimization of crop calendar

Virtual Water Trade

◆Japan relies on foreign water resources
◆When you eat meat, water table decreases

Theme 3 New Observations

Isotope

◆The fifth world best high precision H2O measurement.
◆"Isotope flux" can separate evaporation & transpiration.

Field observations

◆Observation network covering various climate and land cover types.

Theme 4 Experience Hydrology

Measurement of soil temperature

You can try to make an observation tool to measure soil temperature

A miniature of global water cycle

Let’s circulate global water cycle by yourself.

(ford children)

Thank you for your interest.
Feel free to ask questions!
Hydrology is the science which deals with the water as a circulating resource on the earth, such as rain/snow fall, river flow, evapotranspiration, erosion and accumulation, water quality, and systems of water resources and their interactions. Furthermore, global water problems became one of the most important international tasks since United Nations Millennium Declaration in September of 2000. Considering the current situation, hydrology is in charge of not only ensuring adequate supplies of water to ecosystem and human society but also protecting societies from natural hazards. In this point of view, hydrology is the science delivering earth system science to society.

How to Measurement the Hydrological Factors?

1. Satellite

Monitoring the Terrestrial Ecosystem

Cloud Image by Meteorological Satellites

2. Precipitation

Precipitation is very important hydrological factor incoming water on land surface.

3. Evapotranspiration

Eddy covariance system at the tower measures evapotranspiration transferred by turbulence.

4. Soil moisture

TDR installs in the soil and detects soil water content by difference electronic conductance.

5. Soil water depth

This sensor put into the water and converts water pressure into water depth. We apply at paddy to monitor irrigation water.

Relating Observation and Simulation

observation

validation

phenomena

understanding

expression

model

prediction

Experiment Design

- Which instrument useful?

Data Application

- How to use?
The development of hydro-meteorological forecasting and warning systems is a high priority in many countries. An accurate and early warning system can help to minimize disaster damages.

At the Oki & Kanae Lab, several hydro-meteorological early warning systems are under developing on global scale, regional scale, and local scale.

Some results are now real-time available at the website: [http://hydro.iis.u-tokyo.ac.jp/LIVE/] for the three systems: Today's Earth, Today's Japan and Today's Indochina.

**Today's Earth**

**Outputs:**
- Global land surface hydro/energy balance
- River discharge

**Spatial Resolution:** 1 degree (~100 km)

**Time:**
- Run every 12 hours
- Give predictions for coming 84 hours (lead time is about 3 days)

**Today's Japan**

**Outputs:**
- Similar to Today's Earth

**Spatial Resolution:**
- 0.1 degree (~10 km)

**Time:**
- Run every 6 hours
- Give predictions for coming 15 hours (lead time is about 10 hours)

**Today's Indochina**

**Outputs:**
- Land surface hydro-energy flux
- Coming soon: river discharge, river velocity, river depth, etc.

**Spatial Resolution:**
- 72 km for the mother domain
- 24 km for the inner domain

**Time:**
- Run every 6 hours
- Give predictions for coming 72 hours (lead time is about 67 hours)
Early Flood Warning System in Japan and Thailand

Oki & Kanae Lab carried out a research on issues and characteristics of early flood warning system (EFWS) in Japan and Thailand and proposed improvements on them.

**Introduction and Study Areas**

**Ping River Basin - Thailand**
- River Length: 740 km
- Catchment Area: 36,018 km²
- Tributary of Chao Phraya River (162,800 km²) flowing to Gulf of Thailand

**Kariyata and Ikarashi River Basins (Niigata)**
- Kariyata River
  - River Length: 53.5 km
  - Catchment Area: 239.8 km²
- Ikarashi River
  - River Length: 53.5 km
  - Catchment Area: 239.8 km²

**Study Area**
- Chiang Mai: one of the major cities along the river
- Damaged from flood in 2004

**Flood Mitigation Measures**

- **Hard measures** representing structural methods
- **Soft measures** representing non-structural methods

It can be broadly classified into two categories:

**Observation and Data Report System**

<table>
<thead>
<tr>
<th>Location</th>
<th>Measured Data and organization responsible</th>
<th>Measurement Method</th>
<th>Frequency of Measurement (Normal)</th>
<th>Frequency of Report (Normal)</th>
<th>Frequency of Measurement (Flood)</th>
<th>Frequency of Report (Flood)</th>
<th>Transmission Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiang Mai</td>
<td>Rainfall (RID)</td>
<td>Manual</td>
<td>1 time/day (7 a.m.)</td>
<td>1 time/day (6 a.m.)</td>
<td>1 time/day (7 a.m.)</td>
<td>1 time/day (7 a.m.)</td>
<td>Cell Phone</td>
</tr>
<tr>
<td></td>
<td>Water Level (RID)</td>
<td>A-Automatic</td>
<td>A-Continuous</td>
<td>A-1 time day</td>
<td>A-A-All Times</td>
<td>A-Hourly</td>
<td>Cell Phone</td>
</tr>
<tr>
<td>Niigata</td>
<td>Rainfall (JMA)</td>
<td>Automatic</td>
<td>Every 10 min.</td>
<td>Every 10 min.</td>
<td>Every 10 min.</td>
<td>Every 10 min.</td>
<td>Telemetry</td>
</tr>
<tr>
<td></td>
<td>Water Level (Niigata Prefectural Office)</td>
<td>Automatic</td>
<td>Every 10 min.</td>
<td>Every 10 min.</td>
<td>Every 10 min.</td>
<td>Every 10 min.</td>
<td>Telemetry</td>
</tr>
</tbody>
</table>

**Discussion and Conclusions**

- The liberal collaboration between concerned authorities and proper dissemination of information is quite effective in Thailand.
- The delay in Niigata was due to the absence of quantitative concrete criteria. Niigata city has developed a system in internet that provides real time information on rainfall, water level and dam.
- Flood warning is always efficient if the lead time of prediction is high so as sufficient evacuation time can be provided to residents.
- A real-time flood forecasting based on real time observation can be used even in big river basins like Chiang Mai.

**Chiang Mai Flood, 2005**
- Flooding due to heavy overnight rainfall
- Inundation occurs gradually from area with low elevation to areas with high elevation
- There is 6 hours difference between the exceedance of critical level and inundation.

**Niigata Flood, 2004**
- Flooding was due to rainfall and subsequent breakdown of the dike in the river
- Inundation starts at areas near the breakdown of dike
- The duration between critical rainfall and inundation is very short than Chiang Mai.
A global water resources assessment under climate change

It is estimated that…
Along with global warming, water resource distribution will be change
Population growth and economic growth may increase water demand

In the future, How much water will be available? How much water stress does we have?

IIS/NIES Global Integrated Water Resources Model

Method

Meteorological Input

- 1°x1° spatial resolution
- Daily temporal resolution

Land Use, Socio-economic data

- Population, GDP (SRES A1B scenario)
- Industrial water demand, Domestic water demand and Irrigated area was estimated using a simple regression model.
- Crop type, crop calendar was estimated using an agricultural model

Integrated Water Resources Assessment

Results

- Conventional Index
  - Withdrawal to water resources ratio (WWR):

    - Basin A
      - CWD=1.0

    - Basin B
      - CWD<1.0

- New Index
  - Cumulative daily withdrawal to demand ratio (CWD):

    - Basin A
      - CWD=1.0

    - Basin B
      - CWD<1.0

Change in index (between 2010 and 2050)

- Withdrawal to water resources ratio
- Cumulative daily withdrawal to demand ratio

Population under a water-stressed condition

- High stress in both 2010 and 2050
- Medium stress in both 2010 and 2050
- Low/No stress in both 2010 and 2050
- Stress increase in 2050
- Stress decrease in 2050

Population with water-stress will increase.

Population \[10^6\]

Population with water-stress will increase.

Withdrawal to water resources ratio

Cumulative daily withdrawal to demand ratio

Stress is increase in Asian monsoon and Sun-Saharan Africa, where seasonal deviation of precipitation is large.
Virtual Water ~ Invisible movement of water resources ~

Let's compare water resource between Japan and Jordan... 

## Virtual Water and, life of Japanese

### Import of Virtual Water to Japan (Visually required water)

<table>
<thead>
<tr>
<th>Year</th>
<th>Grain &amp; animal product</th>
<th>Total import amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1.3</td>
<td>53.1 billion m³/yr</td>
</tr>
<tr>
<td>2004</td>
<td>1.6</td>
<td>53.1 billion m³/yr</td>
</tr>
</tbody>
</table>

It seems that Japan has abundant water resources. But, a great amount of food import means that Japan imports a great deal of Virtual Water. Water resources in the world is also important for Japan.

### What kind of water?

#### Import of Virtual Water to Japan (Really required water)

- Grain & animal product: 2004
  - Total: 29.5 billion m³/yr
  - Really required water is smaller than Visually required water, because Really required water is estimated by producer base.

#### Virtual Water in the world

- Virtual Water balance in 2000 (m³/yr)
  - Virtual Water trade in 2000 (only main grain)
- Virtual Water trade in 2000 (only main grain)
  - Virtual Water import in each origin

### Water consumption of fast food

- How many bath tubs?
  - Especially, a great deal of water is used for production of meat.

### VW-Adjusted water self-sufficiency ratio

- Water self-sufficiency ratio (WR): Top 10, Major countries, Worst 10

**Virtual Water and, life of Japanese**

**Water resource per person in the Middle East is very few. However, their life is established. Why?**

They depend most for food on import. Therefore, it is not necessary to use water required in order to produce food. It is like having sold oil and buying water resources.

So to speak, import of food is import of Virtual Water.

**Definition of Virtual Water (Oki & Kanae Lab.)**

- Really required water: amount of water resources used in exporting countries (producing country)
- Virtually required water: amount of water resources needed if importing countries (consumer country) will produce same amount of production in own country.

**Advent of concept as Virtual Water**

**Let's compare water resource between Japan and Jordan...**

**Japan**
- Population: 127 million
- Total amount: 400 km³/yr

**Jordan**
- Population: 7 million
- Total amount: 16 km³/yr

**Water resource per person in the Middle East is very few. However, their life is established. Why?**

Author: Toshiyuki INUZUKA, Yadu POKHREL, Masashi KIGUCHI, Dai YAMAZAKI

2007

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[Diagram showing Virtual Water balance and trade, water consumption, and import of Virtual Water to Japan.]
Profile of Oki and Kanae Laboratory

**Professors**

**Professor Taikan OKI**

**Research Topics**
- Global Water Resources Assessment Considering Anthropogenic Activities
- Analysis of global water cycle by using stable isotope measurement and remote sensing
- Integrated River and Water Resources Management in Japan, Asia, and the world

**CV**
- 1987.3 Bachelor of Engineering (University of Tokyo)
- 1989.3 Master of Engineering (University of Tokyo)
- 1989.9 Research Associate (IIS, University of Tokyo)
- 1995.5 Assistant Professor (IIS, University of Tokyo)
- 1995.10 JSPS Oversea Researcher (NASA/GSFC)
- 1997.10 Associate Professor (IIS, University of Tokyo)
- 2002.4 Associate Professor (Research Institute of Humanity and Nature, also at IIS, University of Tokyo)
- 2003.12 Associate Professor (IIS, University of Tokyo)
- 2006.11 Professor (IIS, University of Tokyo)

**Ph.D. Thesis**
水文・水資源予測の大気水循環過程に関する研究 (1993.9)

**Associate Professor Shinjiro KANAE**

**Research Topics**
- Land-Atmosphere Interaction and Global Water Cycle Model
- Future Perspective of Water Cycle and Society in Monsoon Asia
- Climate Change and its Impact on Flood and Drought

**CV**
- 1994.3 Bachelor of Engineering (University of Tokyo)
- 1996.3 Master of Engineering (University of Tokyo)
- 1999.3 Doctor of Engineering (University of Tokyo)
- 1999.4 JSPS Post-Doctoral Research Fellow
- 1999.5 Research Associate (IIS, University of Tokyo)
- 2003.3 Assistant Professor (IIS, University of Tokyo)
- 2003.11 Associate Professor (IIS, University of Tokyo)
- 2003.12 Associate Professor (Research Institute of Humanity and Nature, also at IIS, University of Tokyo)
- 2007.4 Associate Professor (IIS, University of Tokyo)

**Ph.D. Thesis**
Land surface hydrological processes and the variations of water resources in regional climate systems (1999.3)

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**Access**

**Other Members**

(As of May 2007)

- **Staff**
  - Assistant Professor Kei YOSHIMURA
  - Technical Associate Masahiro KOIKE

- **Students**
  - Doctor Course 4
  - Research Fellow 10
  - Master Course 10
  - Undergraduate 1

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