Development of Data Integration and Information Fusion Infrastructure for Earth Observation

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Shibaura Institute of Technology

Asian Water Cycle Symposium
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The University of Tokyo

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The University of Tokyo

Seishi Ninomiya
National Agricultural Research Center

Toshio Koike
The University of Tokyo
Extreme climate, Climate change, Natural disaster, Water and food scarcity → Poverty, Health, Safety

The map of unusual weather (March, 2002)

Percentage of Undernourished people

Understanding and Prediction of Earth System
(Atmosphere, Ocean, Land, Hydrosphere, Biosphere, etc.)
GEOSS 10-Year Implementation Plan

Interoperability and data system
- Facilitating exchange of shared data, metadata, and products
- Data management approach including reprocessing, analysis and visualization of large volumes and diverse types of data
- International information sharing and dissemination
  Internet-based services

Advocate of research and development
- Life-cycle data management
- Data integration and information fusion
- Data mining
- Network enhancement
- Design optimization

2003-06 Evian
G8 Summit
Prime Minister Koizumi’s Remark

2003-07 Washington
1st Earth Observation Summit
Declaration

2004-04 Tokyo
2nd Earth Observation Summit
Framework Communiqué

2005-02 Brussels
3rd Earth Observation Summit
GEOSS (Global Earth Observation System of Systems) 10-Year Implementation Plan
Insufficient of data openness, assignability, unified utilization

Standardization/ Quality Control/ Archive/ Metadata/ Unified format/ Realtime/ etc.

Insufficient of data and information integration
Various information source/ inhomogeneous/ Large volume/ discontinuity

Insufficient of data sharing for crisis and resource management
Translation from data to information/ Information network

Understanding and Prediction of Earth System
(Atmosphere, Ocean, Land, Hydrosphere, Biosphere, etc.)

Extreme climate, Climate change, Natural disaster, Water and food scarcity
Poverty, Health, Safety

Contribution to Scio-economic Needs
Creation of Earth System Intelligence

Development of large scale earth environmental data integration and information fusion system

Improvement of Interoperability and Information Service Functions

Core System

Integrated Methods

Satellite

Data Archive and Quality Control

River

Ocean

Ground-base

Data

Integrated Information

NWP

Flood Forecast

Application to Societal Benefits

Agriculture

Climate

Distributed Systems

Flood Forecasting

Agriculture

Climate

Integrated Information
Flood Disaster Prevention

Development of large scale earth environmental data integration and information fusion system

Core System
Improvement of Interoperability and Information Service Functions

Extreme Event Mechanisms
The environment-friendly agriculture and stable production

Development of large scale earth environmental data integration and information fusion system

Core System

Improvement of Interoperability and Information Service Functions

Agricultural Pest Mechanisms
## Implementation Structure

1. Development of large scale earth environmental data integration and information fusion system

<table>
<thead>
<tr>
<th>Development of large scale data archive/ storage system and data integration infrastructure</th>
<th>Institute of Industrial Science, The University of Tokyo</th>
<th>Masaru Kitsuregawa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of Data Assimilation System</td>
<td>School of Engineering, The University of Tokyo</td>
<td>Toshio Koike</td>
</tr>
<tr>
<td>Development of Advanced Data Visualization and Mining System</td>
<td>Center for Spatial Information Science, The University of Tokyo</td>
<td>Eiji Ikoma</td>
</tr>
<tr>
<td>Development of advanced network infrastructure for huge scale data collection and distribution</td>
<td>Information Technology Center, The University of Tokyo</td>
<td>Masaya Nakayama</td>
</tr>
<tr>
<td>Development of data storage and fusion framework for active data sensor network</td>
<td>National Agriculture and Bio-oriented Research Organization</td>
<td>Seishi Ninomiya</td>
</tr>
</tbody>
</table>
500 TB Data storage (Kitsuregawa Laboratory)
Global ⇔ Regional-Meso ⇔ Basin

Satellite Data Assimilation and Down-scaling

Ocean-Land-Atmos. Coupled Global Model (50~500km)

Soil Moisture Snow

Land-Atmos. Coupled Regional Model (10~100km)

Rain, Cloud Soil Moisture Snow

Global Atmos.-Land Coupled 4DDA

Regional Atmos.-Land Coupled 4DDA

Rain, Soil Moisture

Distributed Runoff Model (100m~1km)

Water Use Flood Control

Satellite Data Assimilation and Down-scaling

Short Forecasting : Initial Condition

Koike Laboratory
Trial Sites of Field Servers

Ninomiya Laboratory
## 2. Development of Mutual Use and Information Service System

<table>
<thead>
<tr>
<th>Project</th>
<th>Organization</th>
<th>Contact Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of Ontology Registry (Recording, Comparing, Editing System</td>
<td>Center for Spatial Information Science, The University of Tokyo</td>
<td>Ryosuke Shibasaki</td>
</tr>
<tr>
<td>of Ontology Information)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information Sharing and Access Support Service using Ontology Registry</td>
<td>Center for Spatial Information Science, The University of Tokyo</td>
<td>Ryosuke Shibasaki</td>
</tr>
<tr>
<td>Distributed data fusion system in agriculture</td>
<td>National Agriculture and Bio-oriented Research Organization</td>
<td>Takuji Kiura</td>
</tr>
<tr>
<td>Development of Distributed Satellite Data Integration System</td>
<td>Japan Aerospace Exploration Agency</td>
<td>Osamu Ochiai</td>
</tr>
</tbody>
</table>
Abnormal Weather / Climate Change / Wind & Flood Damage / Food & Water Crisis → Poverty, Health, Safety

Understanding and Prediction of Earth system

Observation data is insufficient

Standardization/quality/archive/Metadata/format/open to the public/real time

Data integration is insufficient

Various kinds/non-homogeneity/huge volume/time gap

Data sharing is insufficient

Translation Data to information

Information network

Create new Knowledge for Earth System Science

Core System

Centralized Data Integration & Fusion
1. data archive, storage, integration
2. data assimilation, visualization, mining
3. design for database schema
4. data collection and distribution
5. sensor data fusion

Integration of Distributive Data
1. constriction of ontology registry
2. service by ontology registry
3. distinguished DB for agriculture
4. distinguished DB for satellite data

For Social Needs

Metrological information

Integrated use of data

Integrated Information

Global Environmental Data Integration Project

Cooperation with International Organizations

Cooperation with Earth Observation Plans

Satellite data

Oceanic data

Flood data

Earth observation data

Cooperation with International Research Center

Collection/quality management

Integrated Information

Information network

Centralized Data Integration & Fusion

① data archive, storage, integration
② data assimilation, visualization, mining
③ design for database schema
④ data collection and distribution
⑤ sensor data fusion

Integration of Distributive Data

① constriction of ontology registry
② service by ontology registry
③ distinguished DB for agriculture
④ distinguished DB for satellite data

Integrated use of data

Dispersed use

Prediction needs

Agriculture management

Integrated Information

Global Environmental Data Integration Project

Cooperation with International Organizations

Metrological information
Global Environmental Data Integration Project

Integration & Assimilation of Centralized data

Physical Environmental data such as Climate, Water Circulation
- Weather station data
- Satellite data
- Model simulation data, etc

Diversified data in Various fields
Human activity data, Biological data, Ecosystem data such as Agriculture and landuse.
e.g. Statistical data, geographical data, landuse, landcover, water-use data, Agricultural Practice Data, etc

Various data definition and terminology
Different in each countries
Not standardized data

"Trans-disciplinary Dictionary" or Ontology Registry
as a basis to uncover the semantic relations

Geographic Ontology Research Group
As an experimental development,
Agriculture, Landuse, Water use, Focusing Asia
Development Steps of Ontology Registry System for Earth Environmental Data

1. Collection / Registry of Dictionaries/Models
2. Defining/Uncovering Semantic Relations
3. Ontology Visualization/Editing Tools
4. Management as global registry service

1. Modeling for new DB’s
2. Metadata design
3. Integrating Heterogeneous DB’s
4. Extracting information from documents etc.
### 3. Research Development on Earth Observation Data Collection and Data Quality Control

<table>
<thead>
<tr>
<th>Activity</th>
<th>Institution</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement of Satellite Data Collection and Data Processing Methods</td>
<td>School of Engineering, The University of Tokyo</td>
<td>Mikio Takagi</td>
</tr>
<tr>
<td>- Development of Multidimensional Data Integration for Satellite Data</td>
<td>School of Engineering, Shibaura Institute of Technology</td>
<td></td>
</tr>
<tr>
<td>- Development of satellite data reception, management and archiving system</td>
<td>Institute of Industrial Science, The University of Tokyo</td>
<td>Yoshifumi Yasuoka</td>
</tr>
<tr>
<td>Satellite Data Set processing</td>
<td>Japan Aerospace Exploration Agency</td>
<td>Chu Ishida</td>
</tr>
<tr>
<td>Integration of hydrometeorological data</td>
<td>School of Engineering, The University of Tokyo</td>
<td>Toshio Koike</td>
</tr>
<tr>
<td>Integration of Oceanographic Data</td>
<td>Ocean Research Institute, The University of Tokyo</td>
<td>Yutaka Michida</td>
</tr>
<tr>
<td>Integration of research in-situ data</td>
<td>School of Engineering, The University of Tokyo</td>
<td>Katsunori Tamagawa</td>
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</table>
Coordinated Enhanced Observing Period

Data Archive and Data Integration by International Cooperation

Field Observation Data Archive
UCAR
USA

Model Output Archive
Max Planck Institute
Germany

Satellite Data Archive
Data Fusion
Univ. of Tokyo/JAXA
Japan
### 4. Research and development on advanced information application technology

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<thead>
<tr>
<th>Description</th>
<th>Organization</th>
<th>Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>The earth environmental data integration and information fusion for improvement of numerical weather forecasting</td>
<td>Numerical Prediction Division, Japan Meteorological Agency</td>
<td>Ko Koizumi</td>
</tr>
<tr>
<td>Application Research of Earth Observation Integrated Data for Water Management and Its Fused Information</td>
<td>Ministry of Land, Infrastructure and Transport</td>
<td>Kazunori Wada</td>
</tr>
<tr>
<td>- Development of Utilization System in Water Management Application</td>
<td>School of Engineering, The University of Tokyo</td>
<td>Toshio Koike</td>
</tr>
<tr>
<td>- Development of atmosphere, land and river channel coupled model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilization of integrated earth observation data and information fusion for optimal agricultural management</td>
<td>National Agriculture and Bio-oriented Research Organization</td>
<td>Seishi Ninomiya</td>
</tr>
<tr>
<td>- Totalized data assimilation and integration methods for crop managements</td>
<td>Graduate School of Agricultural and Life Sciences, The University of Tokyo</td>
<td>Masari Mizoguchi,</td>
</tr>
<tr>
<td>- Soil-Vegetation Model and Its Model Integration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilization of integrated earth observation data and information fusion for Advance Climate Information</td>
<td>Japan Meteorological Agency</td>
<td>Tomoaki Ose</td>
</tr>
<tr>
<td>- Study on the verification and application of JMA Climate Data Assimilation System</td>
<td>Center for Climate System Research, The University of Tokyo</td>
<td>Teruyuki Nakajima</td>
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Global ⇔ Regional-Meso ⇔ Basin

Ocean-Land-Atmos. Coupled Global Model (50~500km)

SST
Soil Moisture
Snow

Land-Atmos. Coupled Regional Model (10~100km)

Global Atmos.-Land Coupled 4DDA

Regional Atmos.-Land Coupled 4DDA

Rain, Cloud
Soil Moisture
Snow

Rain, Soil Moisture Snowmelt

Distributed Runoff Model (100m~1km)

Water Use
Flood Control

Satellite Data
Low    Moderate    High

Short Forecasting : Initial Condition
Distributed model including dam operations

**Yagisawa Dam**
- Model
- Observation
- Inflow

**Naramata Dam**

**Fujiwara Dam**
- Discharge not based on dam operation rule

**Sonohara Dam**

**Volume at Iwamoto (Outflow point)**
- Without dam
- With dam
- Observation

*Improvement*

※ Discharge not based on dam operation rule
Flood Disaster Prevention

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Extreme Event Mechanisms
The environment-friendly agriculture and stable production

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Insect pest generating area

Meteorological Database

Image and weather network data

High accuracy estimation of insect pest generation area and time

High accuracy prediction of insect pest come flying

Reduced Agrichemical

Trap

Agricultural Pest Mechanisms
Rice planthoppers cannot overwinter in Japan. They migrate from southern China and Taiwan to Japan in *Bai-u* rainy season.

A numerical simulation model can predict the area and period of planthopper migration into Japan. Information of planthopper outbreaks in the migration source region may improve the prediction accuracy.

**Takeoff time:** 2003/06/21-21 UTC
Analysis of earth's global warming phenomenon with use of the integrated database

Using various earth observation data (meteorological observation, satellite observation, research field observation) and a long term reanalysis of climate data, the results of climate formation and global warming phenomenon simulation model are validated.
ADVANTAGE WHICH RESEARCH PROGRESS AND RESULT BRING ABOUT

The 10 Year Implementation Plan for a Global Earth Observation System of Systems (GEOSS) is proposed by the initiative of Prime Minister Koizumi in the Group of Eight Summit held in Evian in 2003 and Japan as one of the Co-chairs has consistently led the intergovernmental working group.

In correspondence with this proposal, "The promotion strategy of earth observations" has been selected by the Council for Science and Technology Policy.

We believe the result achieves a great contribution in each field of the correspondence to the weather, agriculture, water management, climate changes, and disasters not only in Japan but in Asian nations.
ACKNOWLEDGEMENTS

This research will be implemented with the support of the Ministry of Education, Culture, Sports, and Science and their Science and Technology Promotion Research Fund.

We really appreciate their assistance.