

ENHANCE THE LINK BETWEEN REMOTE SENSING AND *IN-SITU* OBSERVATION NETWORK FOR BIODIVERSITY MONITORING

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ABSTRACT:

Biodiversity, the variety of life on Earth, maintains ecosystem services. Since the biodiversity is strongly related to human well-being, the monitoring of biodiversity is significant for global environmental issues. Global Earth Observation System of Systems (GEOSS) is composed of nine Societal Benefit Areas (SBAs), and biodiversity is one of the SBAs, with Group on Earth Observations (GEO) Biodiversity Observation Network (BON) as its primary task. Corresponding to GEO BON, Japanese Biodiversity Observation Network (JBON), the regional network in Japan, was organized and held the first meeting in May 2009 in Tokyo, Japan. Following JBON, Asia-Pacific Biodiversity Observation Network (AP BON), the regional BON over Asia-Pacific region, held the first meeting in July 2009 in Nagoya, Japan. Those BONs have basically eight working groups (WG) and WG 7 of them is mandated for *in-situ* and remote-sensing integration. Remote sensing, by linking with *in-situ* observation, will provide us plenty of biodiversity-related information as ecosystem types and their distribution patterns, which could be the information about habitat structure for organisms. Integrated *in-situ* observations from view points of ecology, ecosystem science, and hydrometeorology are required for remote sensing studies of the biodiversity. Furthermore, those *in-situ* observations should be networked systematically for the interdisciplinary exchange of data, observational philosophy, and technique.

1. INTRODUCTION

1.1 Importance of Biodiversity Monitoring

Biodiversity, the variety of life, maintains the ecosystem on the Earth. Benefits, which our society receives from the ecosystem, are known as the word “ecosystem services” (Costanza *et al.*, 1997). Ecosystem services can be categorized into four groups: provisioning services (*e.g.* food, fuel, pharmaceuticals, and industrial products), regulating services (*e.g.* carbon sequestration and climate regulation), supporting services (*e.g.*

nutrient dispersal and cycling), and cultural services (*e.g.* recreation, ecotourism, and scientific discovery). These services strongly depend on the biodiversity. For example of provisioning services, food, fiber, and pharmaceuticals strongly depend on the existence of adequate biodiversity. Ecotourism of cultural services can be founded by the existence of specific life and ecosystem in the geographical region of the tourists’ destination.

We are facing biodiversity crises, with very high rates of biodiversity loss and biodiversity change (Duraiappah *et al.*, 2005). Conservation of the biodiversity is one of the key issues in terms of the global environmental change, and therefore, the monitoring of biodiversity is necessary.

1.2 Remote Sensing and *In-Situ* Survey for Biodiversity Monitoring

Biodiversity monitoring by remote sensing, a major technology that enables us to scale up the understanding and knowledge on biodiversity from points to geographically wide and continuous region, has to be developed. Remote sensing brings us tremendous possibilities to estimate the climatic and anthropogenic impacts on the biodiversity, and moreover, to predict its temporal change in the future through ecosystem modeling.

It can be thought of as having three major levels of organization of the biodiversity: the genetic level, the species level, and the ecosystem level (Fig. 1) (*e.g.* Group on Earth Observations, 2005). Generally, measurements of remote sensing do not inherently have information about the biodiversity neither at

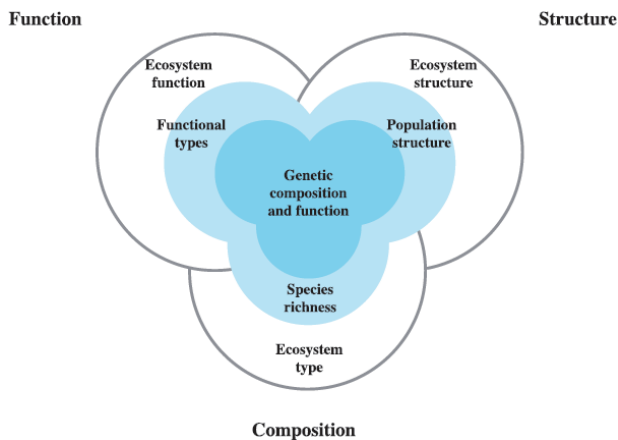


Fig. 1. A conceptual diagram illustrating the multiple levels and aspects of biodiversity. (after Group on Earth Observations, 2005)

ecosystem, species, nor genetic level by itself. Even the highest resolution sensor of the airborne remote sensing would not identify insects. However when the remote sensing is coupled with *in-situ* information, it provides us plenty of biodiversity-related information at the ecosystem level. Moreover the distribution patterns of the ecosystem and habitat which can be delineated by remote sensing provides us ideas on the biodiversity from the species level. This report introduces the international and regional activities on the biodiversity monitoring, and addresses the importance of linkage between remote sensing and accompanied *in-situ* survey.

2. GEO BON

2.1 Outline

Global Earth Observation System of Systems (GEOSS) is composed of nine Societal Benefit Areas (SBAs) each of which has a number of tasks, and Biodiversity is one of the SBAs, with Group on Earth Observations (GEO) Biodiversity Observation Network (BON) as its primary task (Group on Earth Observations, 2005). The GEO BON launch meeting was held in April, 2008 at, Berlin, and GEO BON concept document (Group on Earth Observations 2008) was drafted. Detailed Implementation Plan (Group on Earth Observations, 2010) drafting meeting was taken place in February 2010 at Asilomar, USA.

The vision, mission, and goals of GEO BON can be summarized into following three points (Group on Earth Observations, 2010).

- i) The vision of GEO BON is for a coordinated, global network that gathers and shares information on biodiversity, provides tools for data integration and analysis, and contributes to improving environmental management and human well-being.
- ii) GEO BON has as its mission the improved delivery of biodiversity information and services to users, particularly decision-makers. GEO BON focuses on observing and analyzing changes in biodiversity over time.
- iii) GEO BON is intended to facilitate linkages among the many countries, organizations and individuals contributing to the collection, management, sharing and analysis of observations on the status and trends of the world's biodiversity. It will also identify gaps in and between existing biodiversity observation systems and promote mechanisms to fill them.

2.2 Working Groups of GEO BON

GEO BON has following eight working groups (WG) (Group on Earth Observations, 2010).

WG 1 (genetics / phylogenetic diversity) will facilitate the global observation and monitoring of genetic diversity, using a combination of remote sensing and *in-situ* approaches.

WG 2 (terrestrial species monitoring) focuses on monitoring terrestrial biodiversity at the species level.

WG 3 (terrestrial ecosystem change) will harmonize ecosystem mapping and monitoring so that the data are exchangeable; this will facilitate collaboration in a global context.

WG 4 (freshwater ecosystem change) aims to facilitate the development of a global system for detecting changes in

species, ecological values and ecosystem services in freshwater ecosystems.

WG 5 (marine ecosystem change) challenges to identify, assimilate, and integrate data streams which reflect the broad diversity of marine life as well as the extreme complexity of marine ecosystems.

WG 6 (ecosystem services) aims to map of service delivery over time at all scales from global to local.

WG 7 (*in-situ* / remote-sensing integration through modeling) is focusing on the analytical and modeling approaches needed to achieve such integration across a range of spatial scales (local to global).

WG 8 (data integration and interoperability) is concerned with data integration and interoperability.

2.3 Working Group 7 of GEO BON – *In-Situ* / Remote Sensing Integration and Modelling

This paper for ISPRS Commission VIII highlights WG 7 in particular based on Group on Earth Observations (2010). The work of WG 7 cuts across that of a number of other WGs, as the group has an interest in techniques of relevance to multiple levels of biodiversity (genetic, species, ecosystem) and across multiple environments (terrestrial, freshwater, marine). In many cases these other groups are themselves exploring, planning and facilitating implementation of methodologies that involve integration and modeling of *in-situ* and remotely sensed observations. WG 7 is supporting and complementing, rather than duplicating or competing with, these activities.

At a broader level, and in keeping with the overall philosophy of GEO BON, it is also crucial that WG 7 complements, builds on, and adds value to existing and emerging initiatives in global biodiversity modeling and indicator development outside GEO. In many cases the most important contribution that GEO BON can make in this area will be to facilitate stronger linkage and integration of disparate datasets, models and indicators generated by other such initiatives.

Two parallel streams of WG 7 activities are planned. The first of these will undertake a comprehensive review of needs, capabilities, opportunities, and priorities for using model-based integration of *in-situ* and remote sensing data to assess biodiversity change across scales. This review will help to inform and guide future modeling initiatives within GEO BON and beyond. The second stream of activities will facilitate collaborative establishment and testing of an approach to modeling change in compositional diversity that the group feels is particularly suitable for early commencement.

3. AP BON AND JBON

3.1 Outline

After GEO BON was organized and its concept document was released in 2008, 3rd GEOSS-AP symposium was held in February, 2009 in Kyoto, Japan, and the participants of WG 3 (monitoring changes in ecosystems, biodiversity and ecosystem services) of GEOSS-AP agreed to organize JBON (Japanese Biodiversity Observation Network), the regional BON in Japan, as a voluntary network of Japanese scientists who are working in biodiversity observations not only of Japan but also of the Asia-Pacific region. JBON has held first and second meetings in May 2009 and June 2010 in Tokyo, Japan, respectively.

At the first JBON workshop, the participants of the workshop agreed to organize AP BON (Asia-Pacific Biodiversity Observation Network) by inviting scientists in the Asia-Pacific region. First, second, and third AP BON meetings were held in Nagoya (July 2009), Tokyo (February 2009), and Nagoya (March 2010), Japan, respectively. The third meeting provided an opportunity for drafting an AP BON implementation plan.

AP BON and JBON have following working groups corresponding GEO BON. AP BON does not contain WG 6 and WG 8 at present.

- WG 1 (AP BON, JBON): Genetics / phylogenetic diversity
- WG 2 (AP BON, JBON): Terrestrial species monitoring
- WG 3 (AP BON, JBON): Terrestrial ecosystem change
- WG 4 (AP BON, JBON): Freshwater ecosystem change
- WG 5 (AP BON, JBON): Marine ecosystem change
- WG 6 (JBON): Ecosystem services
- WG 7 (AP BON, JBON): *In-situ* / remote-sensing integration
- WG 8 (JBON): Data integration and interoperability

3.2 WG 7 of AP BON and JBON

WG 7 of JBON has been organized by several scientists who work in the field of ecology and satellite/airborne remote sensing studies, while WG 7 of AP BON is still under organizing stage. The target and activities of WG 7 of AP BON and JBON are basically corresponded to the activities of WG 7 of GEO BON, and we recognize our concepts and activities must be cross-cut to the other WGs, such that covering terrestrial ecosystems, lake and river ecosystems, and coastal marine ecosystems.

Also WG 7 focuses on bridging *in-situ* observations of ecosystem (structure and function) and biodiversity with the satellite remote sensing of ecosystem structure including its temporal and spatial variation by networking super-sites and related observation networks.

Practical linkage of remote sensing and *in-situ* biodiversity observation requires intensive efforts to fill the gaps between these disciplines which contains various differences such as in the observation techniques (indirect vs. direct), spatial and

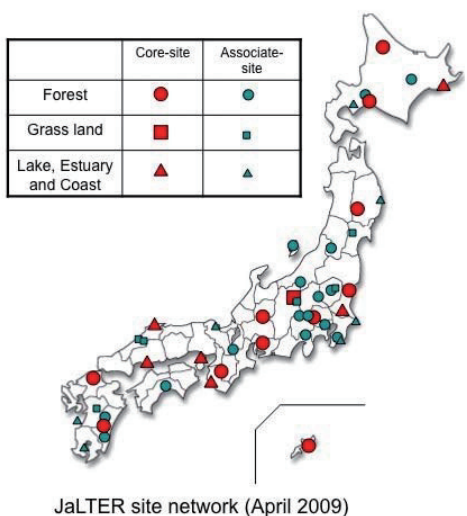


Fig. 2 Site distribution of JaLTER.

Linking efforts in J-BON and AP-BON (est. 2009)

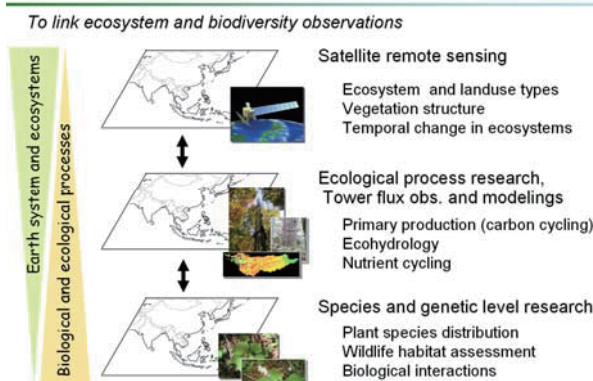


Fig. 3 Concept of efforts to link the *in-situ* and remote sensing observation for the biodiversity monitoring.

temporal resolution of the research interests, and the mutual understanding on the viewpoints having different background of specific interests. To support those linkage, some new philosophy and platforms must be prepared, which would cover both observation activities and needs.

In addition, the current tasks in the global climate change assessment absolutely request us to precede these linking efforts by considering their consequences with ecosystem structure and functioning. Ecosystem structure (vegetation types and density) and functioning (carbon cycle, water and energy budget, etc.) are the very bridging aspects for both Earth system and biodiversity. Therefore, we proposed that WG 7 enhances the linkages among biological-physical and biological-biological information so that it could provide more valuable information about biodiversity at the species level.

We facilitate the tasks by two types of efforts.

- i) Intensive collaborative research and knowledge sharing especially in super-sites of ecosystem function study and ecological studies such as those contributing to JapanFlux (Japan Flux Network) and JaLTER (Japan Long Term Ecological Research) in Japan (see Fig. 2 for the site distribution). This effort firstly confirms the linkage among various information among plots, and then, estimate the biodiversity distribution outside by inter/extrapolating the relationships aiming to link with remote sensing (Fig. 3).
- ii) Extensive collaborative research with field scientists with knowledge and information about biodiversity at the species level. This effort will provide finer and richer information about vegetation distribution which would be essential for the direct satellite observation and also for the habitat estimation for the non-observable species.

These activities should involve the collaboration with the remote-sensing-related communities or institutions such as Japan Aerospace Exploration Agency (JAXA) and Japan Agency for Marine-Earth Science and Technology (JAMSTEC). Knowledge sharing by deep collaboration and mutual understanding from the philosophical basis of the integrated ecosystem science must be the key process to filling the gaps for the required tasks in AP BON and JBON. WG 7 thus works to cross cut other WGs and to bridge those various viewpoints and techniques, and contributes to provide with new insights into the integrated observation strategy by networking the observation networks.

4. PROSPECTED ACTIVITIES OF WG 7 OF AP BON AND JBON

- i) WG 7 undertakes a comprehensive review of needs, capabilities, opportunities, and priorities for integration of *in-situ* and remote sensing data to assess biodiversity change across scales.
- ii) In particular, basic practical concepts and practices of linking *in-situ* and satellite remote sensing for forest ecosystem structure and functions will be established, in super-sites of JapanFlux and JaLTER (Takayama (Fig. 4), Tomakomai, and Mase, etc.).
- iii) Networking among countries in Asia-Pacific region will be facilitated by gaining participation of more scientists from those countries.
- iv) WG 7 develops database of biological information from existing *in-situ* observation plots for remote sensing data.
- v) WG 7 facilitates to make thematic maps of land use and ecosystem types in relation to biodiversity monitoring.
- vi) Models to clarify the consequence between ecosystem function and biodiversity will be developed, with special focus on carbon and nutrient cycling.

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APPENDIX: Member of Remote Sensing working group for JBON (alphabetical order)

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Fig. 4 A super-site in the temperate forest at Takayama, Japan. Picture was taken from the top of ecological tower.