10th Anniversary of Sentinel Asia

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Space-Based Disaster Management Support in the Asia-Pacific

By

Kazuya Kaku, Alexander Held, Masahiko Nagai and Koji Suzuki

Cambridge Scholars Publishing

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This book first published 2024

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-0364-1715-4
ISBN (Ebook): 978-1-0364-1716-1

This book is dedicated to everyone
who has fought, is fighting, or may fight disasters.
Royalties from this book
will be donated to disaster management efforts.

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FOREWORDS

The concept for Sentinel Asia was borne during APRSAF-11 in 2004, when I began my role as Head of the CSIRO Office Of Space Science and Applications–COSSA', after having just established 'Sentinel Hotspots' in Australia. Sentinel Hotspots was established by CSIRO to help detect and track bushfires (wildfires) day and night across the vast Australian continent, using earth observation satellite technologies. During APRSAF-11, several representatives of regional agencies expressed their interest in establishing something similar for the Asia-Pacific region, which has proportionately the largest incidence of natural disasters around the world. It was noted also that 'Sentinel Asia' should cover a wider range of disasters, beyond just bushfires in Australia, including floods, landslides and earthquakes, some of which may be considered rather small in magnitude to trigger satellite acquisitions under the UN Charter for Disasters. Since formal adoption and establishment in 2005 at APRSAF-12 and led by JAXA, the membership of the Sentinel Asia family has grown to 116 organisations in 29 countries/regions in the region, and has provided satellite derived information by emergency observations on more than 450 regional disasters.

I personally have been very proud to have been part of this program, since it has been a great collective, regional achievement that we, as 'foundation partners', believe has also positively supported many disaster response and recovery efforts in these countries and benefitted the society in our region at large.

July 15, 2024

Alexander Held

Mission Lead
AquaWatch Australia
CSIRO Space and Astronomy

I am pleased that Sentinel Asia has celebrated its 10th anniversary. This book provides Sentinel Asia's history, framework, implementation approach, how it works, achievements, and others as of the 10th anniversary of Sentinel Asia, which shows empirical case study of how to apply satellite remote sensing to disaster management. The Sentinel Asia (SA) initiative is a voluntary, grassroots, and best-efforts–based collaboration between regional space agencies and disaster management agencies for regional humanitarian purposes, applying satellite remote sensing and Web-GIS technologies to assist disaster management in the Asia-Pacific region. Under the framework of the Asia-Pacific Regional Space Agency Forum (APRSAF), it was proposed in 2004, agreed to be implemented in 2005, began implementation and operation in 2006, and is still in operation today. This is the result of the collaboration and efforts of many related organizations and stakeholders. This book summarizes SA's activities up to around 2014; I was involved in the launch and implementation of SA at the Japan Aerospace Exploration Agency (JAXA) from 2006 to 2014.

In recent years, there has been a generational change in personnel at SA member institutions, and I believe that leaving a record of SA's early days will be meaningful for the future development of SA. This book features case studies from 2006 to 2014 (including not only emergency observations to support disaster response, but also prevention/mitigation/preparedness support and recovery support) as well as the voices of member institutions; I hope that this book will contribute to the further development of SA.

SA is a framework for collaboration among the space community (space agencies), the disaster management community (ADRC and its member organizations, and disaster management organizations), the international community, and academia (university, research and technical institutes); the authors of this book also have such a lineup. This book will be useful for other international collaborations as well.

July 29, 2024

Kazuya Kaku

Visiting Researcher
Asian Disaster Reduction Center (ADRC)

Japan has experienced a series of large-scale disasters that have caused extensive damage. In Asian countries as well, various large-scale disasters have occurred in various regions, and the demand for remote sensing technology for detection and response has been increasing. In Southeast Asia in particular, ground infrastructure is not always well developed, and expectations for initial response to disasters using satellite data are extremely high.

JAXA and other space and disaster organizations have been taking the lead in disaster response using satellite data through the framework of Sentinel Asia. Sentinel Asia is an international cooperative project launched to contribute to disaster management in the Asia-Pacific region through space technology.

On the other hand, one of the most important issues for the wide use of space technology, as typified by satellite remote sensing, in disaster response is the analysis of satellite images and the speeding up of their processing. Expectations are rising for AI technologies such as deep learning to interpret images and extract information, but the image data, including that of UAVs, is extremely large and diverse, and there are significant challenges from the perspective of human resource development, including technological development and know-how accumulation. In particular, image analysis techniques and application methods differ greatly depending on the purpose of the analysis, and it is essential to accumulate data through practice to advance the techniques and accelerate human resource development. In this sense, it is a very effective and unique approach to promote technological development and human resource development through disaster response in Sentinel Asia.

August 1, 2024

Masahiko Nagai

Director / Professor
Center for Research and Application for Satellite Remote Sensing
Yamaguchi University

I have been involved in the disaster management community since the inception of Sentinel Asia, serving as Executive Director and then Program Director at the Asian Disaster Reduction Center (ADRC). When Sentinel Asia was first established, the ADRC was also working to promote the use of satellite technology among the national disaster management organizations of its member countries. At that time, there was minimal understanding of satellites, and even mentioning the word "satellite" could halt further discussion. Many individuals in the disaster management field were not space scientists, making space technology seem distant and abstract to them. It was a significant challenge to demonstrate that space technology could be valuable and practical for disaster emergency response. To address this, we introduced satellite technology through capacity development programs, broadened perspectives, and laid a solid foundation. We invited organizations from various countries to participate in Sentinel Asia. Some organizations, including those from Japan, were initially skeptical about what Sentinel Asia could achieve. This skepticism indicates that awareness of Sentinel Asia is growing and attitudes toward satellite technology are evolving. I believe that satellite technology has now become a standard tool in disaster management. Times are changing, and I am pleased to have been involved with Sentinel Asia during this transformative period.

However, I believe we have not yet reached a point where satellite technology is absolutely indispensable. While it has become crucial for emergency response, there is still room for improvement in its application for risk assessment and other purposes. The core of utilizing space technology in disaster management lies in risk assessment and monitoring. The United Nations Office for Disaster Risk Reduction (UNDRR) focuses on disaster risk reduction, and Sentinel Asia Step 3 is expected to contribute to the Sendai Framework for Disaster Risk Reduction (DRR) 2015−2030. This book aims to provide future generations with insights for the next decade of Sentinel Asia.

Since the inception of Sentinel Asia, I have had the pleasure of working with some truly outstanding colleagues. One of them is Dr. Lal Samarakoon, an expert in GIS technology and remote sensing technology, who served for many years as the Director of the Geoinformatics Center (GIC) at the Asian Institute of Technology (AIT). Originally from Sri Lanka, he had a gentle personality and was fluent in both English and Japanese. I am proud to have contributed to Sentinel Asia as a co-chair of the Steering Committee alongside him. He was always a good friend, an excellent leader, and a kind-hearted advisor. His passing on July 12, 2024, is a great loss, and I would

like to express my deepest condolences.

August 28, 2024

Koji Suzuki

Project Director
Asian Disaster Reduction Centre (ADRC)

Author Contributions

Kazuya Kaku had the original idea for this book and contributed to chapters 1 to 6, and the epilogue;
Alexander Held contributed to chapters 1 to 3;
Masahiko Nagai contributed to chapter 8;
Koji Suzuki contributed to chapter 7; and
all authors reviewed and approved the submitted manuscript.

ACKNOWLEDGEMENTS

We wish to gratefully acknowledge all the members of the Asia-Pacific Regional Space Agency Forum (APRSAF), the Sentinel Asia (SA) Joint Project Team, the JAXA SA team, and the JAXA domestic disaster response support team for their contribution and collaboration in promoting the project, especially:

Dr. Renato U. Solidum, Jr. of the Department of Science and Technology (DOST) and Dr. Arturo S. Daag of the Philippine Institute of Volcanology and Seismology (PHIVOLCS) in the Philippines for leading the SA success story;

Dr. Manzul Kumar Hazarika of the Asian Institute of Technology (AIT) for his contribution to emergency satellite data analysis and the SA mini-project;

the late Dr. Lal Samarakoon, former Director of the Geoinformatics Center (GIC) at the AIT, for his contribution to SA as a co-chair of the Steering Committee and others;

Dr. Ming-Chih Cheng and Mr. Bo Chen of the National Applied Research Laboratories (NARLabs) for their contribution to emergency observation using FORMOSAT-2, particularly after the termination of ALOS operation;

Professor Emeritus Masami Fukuda of Hokkaido University for leading the SA wildfire working group (WG) as the chair. He introduced me to the field of wildfire management and its close relationship to the mitigation of global warming;

Professor Emeritus Toshihisa Honma of Hokkaido University for leading the JST/JICA project on wildfire and carbon management in a peat forest in Indonesia;

Dr. Masami Tokuno of the Meteorological Research Institute, Japan Meteorological Agency (at that time) for his instruction about hotspot detection using MTSAT;

Dr. Orbita Roswintiarti and Mr. Agus Hidayat of the Indonesian National Institute of Aeronautics and Space (LAPAN) for their contribution to the wildfire WG and disaster response in Indonesia;

Mr. Kwoh Leong Keong and Dr. Liew Soo Chin of the National University of Singapore for their contribution to the wildfire WG;

Professor Hiromichi Fukui of Chubu University for his contribution to Step-1 Web-GIS and leading the SA glacial lake outburst flood (GLOF) WG as the co-chair;

Mr. Basanta Shrestha of the International Center for Integrated Mountain Development (ICIMOD) for leading the GLOF WG as the co-chair;

Mr. Kazuhiko Fukami and Mr. Yoichi Iwami of the International Centre for Water Hazard and Risk Management under the auspices of UNESCO (ICHARM) for leading the SA flood WG as the chairs;

Dr. Giriraj Amarnath of the International Water Management Institute (IWMI) for leading the flood WG as the co-chair and his contribution to emergency satellite data analysis; and

Dr. Yoshiyuki Kaneda of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) (at that time) and Professor Shunichi Koshimura of Tohoku University (successor) for leading the SA tsunami WG as the chairs.

A part of wildfire WG activity (refer to Section 4.3.6.5) is funded under the Science and Technology Research Partnership for Sustainable Development (SATREPS) scheme, which is jointly coordinated by the Japan Science and Technology Agency (JST) and the Japan International Cooperation Agency (JICA).

PART I

PROGRAM-LEVEL DECISION

CHAPTER ONE

PROGRAM-LEVEL DECISION AT APRSAF

1.1 Background

The application of satellite remote sensing to disaster response support under an international framework began around 2000, when satellite-based Earth observations were first envisaged as a tool to rapidly assess disaster situations around the world by the International Charter: Space and Major Disasters (hereinafter referred to as "the International Charter" or "the Charter") (Bessis et al., 2004) and the United Nations (UN) (Voigt et al., 2016).

JAXA has begun engaging in disaster management support activities using the Advanced Land Observing Satellite (ALOS, nicknamed "Daichi"), launched in January 2006, not only within Japan but also for overseas disasters through the international collaboration framework of Sentinel Asia (SA) and the International Charter. This book provides a detailed explanation of SA. The SA initiative (Kaku et al., 2006; Kaku et al., 2013; Kaku, 2019a; Kaku, 2019b, chap. 6; Kaku, 2021, chap. 3) is a voluntary, grassroots, and best-efforts–based collaboration between regional space agencies and disaster management agencies for regional humanitarian purposes, applying remote sensing and Web-GIS technologies to assist disaster management in the Asia-Pacific region, born by the Asia-Pacific Regional Space Agency Forum (APRSAF). Sections 1.2 to 1.4 are reprinted with some modifications from the APRSAF website.

Trend of natural disaster occurrence (ADRC, 2023)

The trend of natural disaster occurrence analyzed using EM-DAT 2022 data is shown in Figure 1-1. From 1900 to 2022, disaster occurrence has been on the rise. Globally, the average number of disasters has risen from an average of 56 disasters per year in the 1960s (peaking at 81 in 1966) to an average of 363 disasters per year in the most recent decade (2012-2022). Moreover, 388 disasters occurred in 2022, which is more than three times the average number of disasters from 1990 to 2021 (119). Throughout the entire period

from 1900 to 2022, floods (39%) and storms (31%) were the most frequently occurring disaster types.

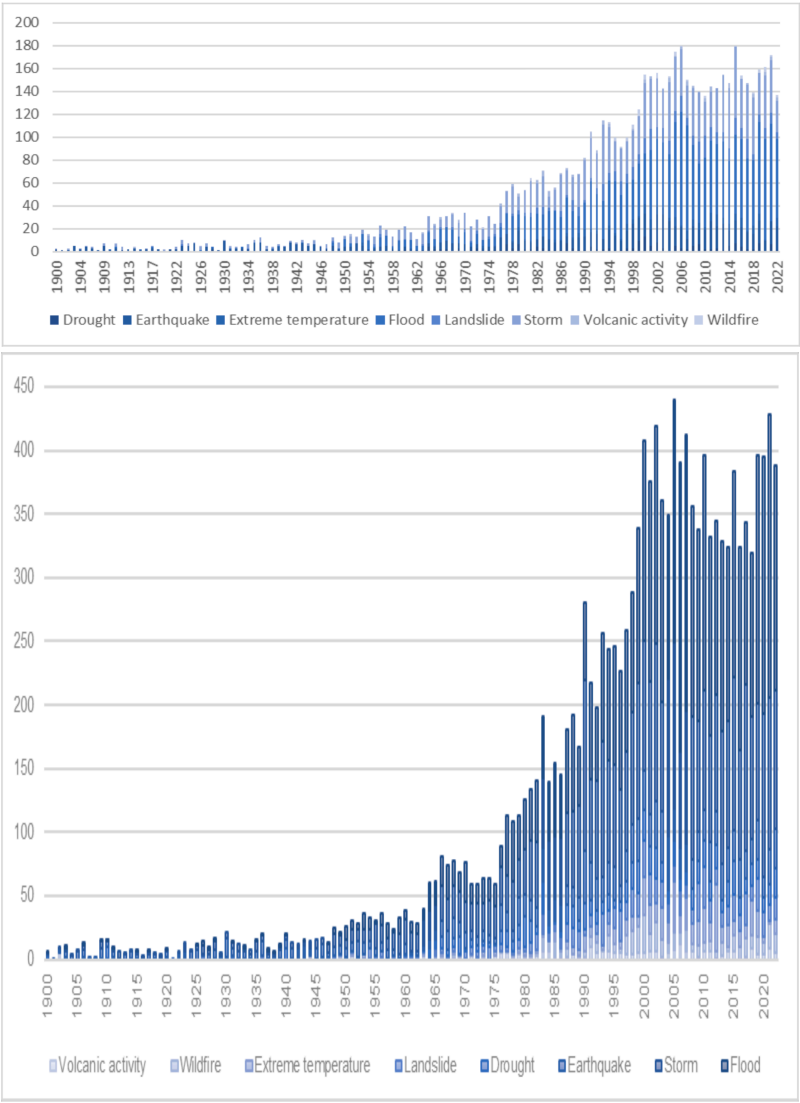

Fig. 1-1. Trends in natural disaster occurrence from 1900 to 2022 (EM-DAT/CRED, 2023). The top figure shows trends in Asia; the bottom, global trends. (ADRC, 2023)

In Asia, the average number of disasters per year from 1992 to 2021 is 141. Over the past three decades, most types of disasters have shown an increasing trend, while wildfires have shown a decreasing trend. Similar to the global trend, floods, storms and earthquakes are the most frequent disasters in Asia from 1992 to 2021. Most of the disasters occur in Southeast Asia, followed by South Asia, East Asia, West Asia and Central Asia.

1.2 APRSAF

In response to the declaration adopted at the Asia-Pacific International Space Year Conference (APIC) in 1992, APRSAF was established in 1993. APRSAF has been holding annual meetings, jointly organized by the Ministry of Education, Culture, Sports, Science and Technology in Japan (MEXT), Japan Aerospace Exploration Agency (JAXA), and organizations of host countries. The APRSAF was established to enhance space activities in the Asia-Pacific region. Space agencies, governmental bodies, international organizations, private companies, universities, and research institutes from over 40 countries and regions take part in APRSAF, the largest space-related conference in the Asia-Pacific region. The increasing attendance of high-ranking officials and participants from industry at APRSAF events provides opportunities to discuss international cooperation for space activities in concrete terms.

APRSAF currently organizes five working groups - Satellite Applications, Enhancement of Space Capability, Space Education, Space Frontier, Space Policy and Law - and Space Industry Workshop to share information about the activities and future plans of each country and region in these respective areas. APRSAF also supports the establishment of international projects as solutions for common issues, such as disaster management and environmental protection, so that participating parties will benefit from mutual cooperation.

APRSAF Characteristics

Open and flexible regional cooperative framework:

(1) In view of the diversity of needs in the Asia-Pacific region for space utilization and related developments, APRSAF provides a flexible framework rather than legally binding agreements.
(2) The open framework of APRSAF enables various entities to participate in its activities.

Voluntary and cooperative activities:

(1) Participating parties carry out their projects in a cooperative and voluntary manner.
(2) Working groups actively organize workshops throughout the year.

Concrete cooperative activities to solve regional issues:

(1) APRSAF establishes international projects to deal with common issues in the Asia-Pacific region and implement concrete actions such as:
   - Sentinel Asia for disaster management,
   - SAFE (Space Applications for Environment) for environmental issues)

   [Completed],
   - Kibo-ABC (Asian Beneficial Collaboration through "Kibo" Utilization),
   - NSLI (National Space Legislation Initiative).

1.3 APRSAF-11

In recent activities of the Earth Observation Summit and the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), it has been globally recognized that the importance of contributing to the collection and provision of more advanced and beneficial observation information through the use of leading-edge space technologies, and the promotion of capacity building in developing countries, in order to take appropriate measures for various global issues such as global warming, water cycle change and natural disasters. On the basis of such movements in the world, APRSAF intends to work as a forum to make further expansion of space development and applications in the Asia-Pacific region, by gathering opinions widely from this region. Under the main theme of "Toward Expansion of the Space Community", the APRSAF-11 was held on November 3 to 5, 2004, at the National Convention Centre, Canberra, Australia. More than 100 local and Asia-Pacific participants and observers gathered at this forum (see Fig. 1-2).

Fig. 1-2. The 11th Session of the Asia-Pacific Regional Space Agency Forum (APRSAF-11), held at the National Convention Centre, Canberra, Australia, in November 2004. Source: APRSAF website.

Recommendations of the 11th Session of Asia Pacific Regional Space Agency Forum (APRSAF-11)

All APRSAF-11 participants, recognizing the importance of expanding the space communities in our region, have adopted the following recommendations (excerpts):

(1) To promote and strengthen concrete cooperative activities through APRSAF, such as pilot projects for effective disaster, environmental and natural resource management; broadband rural communications; and educational promotion activities.
(2) To promote space applications which will meet the needs of end-users such as national disaster management authorities, the Asian Disaster Reduction Center (ADRC) and people in isolated areas, by providing useful and efficient information and tools.
(3) To strengthen the close relationship with global and regional frameworks such as Global Earth Observation System of Systems (GEOSS), UN Regional Space Applications Program (RESAP), World Climate Research Program (WCRP) and International Strategy for Disaster Reduction (ISDR), and to seek to harmonize APRSAF activities with them.
(4) To enhance capacity building activities to strengthen the capability of our region.

1.4 APRSAF-12

Being reminded of the recent loss of numerous lives and enormous damages suffered in the Asia-Pacific region resulting from earthquakes and Tsunamis, particularly the Indian Ocean tsunami disaster of December, 2004, APRSAF-12 participants renewed the importance for the countries in the region, sharing similar climate and geological conditions, to cooperate even more closely in order to mitigate risks of disasters at the regional level. Satellite systems, not directly affected by disaster, can be stable and are highly reliable tools for disaster management, information gathering and communications in connection with ground systems. APRSAF-12, held between October 11th and 13th, 2005 at the Kitakyushu International Conference Center, under the main theme entitled "Maximizing Space Benefits for the Society", focused on the use of space technology to cope with environmental problems, to prevent and mitigate risks of disasters, to improve quality of life and to bring about better future for the next generation (see Fig. 1-3).

Fig. 1-3. The 12th Session of the Asia-Pacific Regional Space Agency Forum (APRSAF-12), held in Kitakyushu, Japan, October 2005. Source: APRSAF website.

Recommendations of the twelfth session of the Asia-Pacific Regional Space Agency Forum (APRSAF-12)

Stressing the importance of maximizing space benefits for the society through the generation and provision of effective and efficient space-derived information and space-based tools to respond to the needs of end-users, recognizing the need to further expand the space community in the region, expressing deep condolences for the recent loss of numerous lives and enormous damages suffered in the Asia-Pacific region resulting from earthquakes and tsunamis and recognizing the need to promote space utilization toward the realization of the safe and secure society by minimizing damages caused by natural disasters, the participants of APRSAF-12 adopted the following recommendations (excerpts):

(1) To strengthen international cooperation to take concrete actions toward the establishment of a disaster risk management system within the framework of APRSAF, recognizing the timeliness of establishing such a system, with the participation of as many entities as possible such as space agencies, disaster management agencies, as well as relevant regional and international entities;
(2) **To take concrete steps toward the establishment of the above disaster risk management system, and as the first step, to implement "Sentinel Asia" pilot project through the formation of the joint project team at the earliest possible date in order to refine the details of the implementation of the project**;
(3) To accelerate the promotion of the applications of the Wideband InterNetworking engineering test and Demonstration Satellite (WINDS) for the benefit of Asia-Pacific region, including those for disaster management;
(4) To make continuous efforts to increase awareness among the general public, especially youth, and decision-makers of the importance of space applications to promote sustainable development through variety of education and awareness activities; and
(5) To enhance capacity building activities to strengthen the capability of the Asia-Pacific region to use and benefit from space science and technology and their applications.