Preface

Human-initiated biomass burning has increased significantly over the last century. This special issue, "Biomass Burning and its Impacts on Earth's Environment," assesses the impact of biomass burning as a driver on global change.

The impact of biomass burning on the Earth's environment is schematically shown in Fig. 1. At first, biomass burning directly impacts terrestrial ecosystems, for example through deforestation, loss of biological diversity, and loss of soil nutrients, while we should be careful of considering nutrient input to surface soils in shifting cultivation. Secondly, many trace gases and aerosols are emitted into the atmosphere, and in particular, primary and secondary aerosols can affect not only climate change but also human health.

In recent years, the IPCC has pointed out that in terms of climate change, twenty percent of carbon emissions can be attributed to reduction of forest area (IPCC-AR4). As such, forest fires, a major cause of deforestation, can cause not only direct CO_2 emissions but also indirect CO_2 emissions. In terms of forest and grassland fires, it has also been pointed out that not only CO_2 but large amounts of other trace gases and aerosols are generated, affecting the global environment in various ways. The effects of activities such as burning wood for fuel or slash and burn agriculture cannot be ignored either. In that sense, biomass burning, including vegetation fires among many other things, can be regarded as a major global environmental issue.

The purpose of this special issue is to introduce the current situation of biomass burning in the Asian region, comparing biomass burning between Asia and Africa, and to elucidate the uncertainty of satellite image analysis of biomass burning and the impact of biomass burning on climate change, through the radiative budget in the atmosphere.

Biomass burning occurs not only in tropical regions, but also in temperate and boreal regions. It is well known that many types of biomass burning occur throughout the world, such as large-scale forest fires, burning of bio-fuels, savanna burning, shifting cultivation, deforestation, residue burning of agricultural wastes, and so on, although definitions often overlap.

In Asia, biomass burning occurs in a different style from north to south. In this special issue, biomass burning in Asia is introduced from Siberia, Mongolia, Laos, Thailands, Indonesia, and India. Siberia is located in a boreal region, where forest fires have been frequently observed for these ten years, especially in 2002 and 2010. A possible reason for biomass burning in Siberia is considered to be severe drought in that region, and the burning of peat accumulated below the surface is also one of the fire sources, as in the case of the tropical region of Kalimantan and Sumatra, in Indonesia. In contrast, biomass burning in Africa, where vegetation fires predominate, occurs under a different situation from that in Asia.

In this issue, we have selected regions in the world where vegetation fires have become a particularly important issue: Asia (Siberia, Mongolia, Laos, Thailand, Indonesia, India) and Africa. We commissioned researchers active in this field to create new reports on the situation of such vegetation fires and their impact on the environment, using remote sensing technologies to analyse large areas in relation to greenhouse gas (GHG) emissions, etc.

In Siberia, it is known that a unique forest ecosystem called taiga has developed over a vast permafrost terrain, a biome which stores large amounts of carbon. It is also an area where, due to global warming, vegetation fires, etc., there is concern about GHG emissions and deforestation caused by the melting of the permafrost. This area has low rainfall levels in summer, and the permafrost supports forests in places where they would otherwise not exist. Because of this, the summers are dry and there are many natural fires. In regard to this, we asked Dr Hiroshi HAYASAKA, an Associate Professor of the Division of Human Environmental System, Graduate School of Engineering, Hokkaido University, report on "Forest fires and greenhouse gas emissions in Siberia." He has studied global environmental problems and has specialised for many years in the study of vegetation fires and climate change in the Siberian taiga and tropical swamp areas.

Mongolia is much like Siberia in terms of latitude, but has vast grasslands as well as forest areas. It constantly suffers from vegetation fire problems, which are not just a significant environmental problem but an economic problem too. Although these vegetation fires are primarily caused by low rainfall levels and strong monsoons, 95% are attributable to human activities. On the other hand, being a relatively flat terrain which is not subdivided for land use,

this region is very suitable for satellite remote sensing observations. Dr Magasar ERDENETUYA is a Senior Remote Sensing Specialist from the National Remote Sensing Centre of Mongolia, and has reviewed for us the vegetation fire situation in Mongolia via remote sensing in "Burning Biomass in Mongolia."

Laos, naturally a land of forests, has many mountains and has traditionally logged these forests and engaged in slash and burn agriculture. This was a carbon-free, sustainable way of using the land, but land usage patterns have changed in recent years, resulting in rapid deforestation, and it is fast becoming a CO_2 emitting region. Dr Yoshio INOUE of the National Institute for Agro-Environmental Sciences, who has been researching slash and burn agriculture in this region, has studied sustainable future land use systems based on scientific knowledge, whilst making good use of Laos's current land use situation and the advantages of traditional slash and burn agriculture in "Roles and Impacts of Biomass Burning in Slash and Burn Land Use in Tropical Mountains: A Case Study in Laos."

Also, Dr Sébastien BONNET and Dr Savitri GARIVAIT (the Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Thailand) report on an investigation into the seasonal variability of open biomass burning activities in the Greater Mekong Sub-Region (GMS) with a focus on carbon monoxide (CO) and total particulate matter (TPM) or aerosol emissions which was conducted in order to document the characteristics of this significant source of air pollutants in the region Indonesia was once covered with vast tropical rainforests, and like Laos, forest use was sustained by methods such as slash and burn agriculture. However, because of government policies regarding Javan migrants and because of there being many flat areas, in recent years, many forests have been lost to massive vegetation fires. Specifically, the primary cause of these vegetation fires is burning for creation of oil palm plantations and other agricultural purposes. In this special issue, Dr Bambang Hero SAHARJO of the Forest Fire Laboratory, Faculty of Forestry, Bogor Agricultural University, Indonesia, reports on the current situation of forests in Indonesia, and on the various trace gases emitted in vegetation fires in peat lands in "Indonesian Forest and Peatland Burning."

India has achieved rapid economic growth in recent years, and with its massive population, it is expected to occupy a major position in the global economy. In India, the area of forest seems actually to be increasing. However, the current situation with regard to deforestation due to vegetation fires is as yet unclear. As such, Dr K.V.S. BADARINATH and Dr Krishna PRASAD VADREVU report on India's current situation regarding forests and forest fires and the GHGs emitted by them in "Carbon Dioxide Emissions from Forest Biomass Burning in India."

Finally, we looked at Africa. There are many types of forest in Africa, ranging from tropical rainforests to desert, but in this issue we look in particular at the especially fire-prone sub-Saharan regions and Africa's current situation with regard to vegetation fires. Indeed nearly half of the trace gases and particles emitted by fires are supposed to originate in sub-Saharan Africa. For this reason, there is a need to study the reality of the situation in Africa. In Africa, apart from fires, the use of firewood as fuel is also a major cause of emissions. Dr Robert J SCHOLES, Dr Sally ARCHIBALD and Dr Graham von MALTITZ of South Africa's CSIR National Resources and Environment present a study on the current situation of CO_2 emissions from the sub-Saharan region in "Emissions from Fire in sub-Saharan Africa: the Magnitude of Sources, their Variability and Uncertainty." As is apparent from the title, this region is vast, and the situation regarding vegetation fires seems to be still quite uncertain.

In the following two papers, we focus on remote sensing technology, which is a useful tool in the observation of forest fires, and on emissions of trace gases and aerosols produced by vegetation fires. The current situation regarding satellite remote sensing technology, particularly in Asia is reviewed, and effects of aerosol emissions from vegetation fires could have on climate change is estimated.

Dr Chris JUSTICE and Dr Krishna PRASAD VADREVU, both from the Department of Geography of the University of Maryland, USA, are authorities particularly in the field of land analysis by remote sensing. They briefly review the potential of satellite remote sensing data for mapping and monitoring vegetation fires using MODIS datasets. They also comment on the Global Observation of Forest Cover/Global Observations of Land Dynamics (GOFC-GOLD)'s world-famous research on forest fires, particularly on matters such as GOFC-GOLD Fire Implementation Team activities in "Vegetation Fires in the Asian Region: Satellite Observational Needs and Priorities."

The earth's atmosphere contains trace gases and aerosols including GHGs, and which impacts greatly on global climate change (IPCC-AR4). Dr Toshihiko TAKEMURA, an Associate Professor at the Research Institute for Applied Mechanics (RIAM) uses a global aerosol climate model to estimate how aerosols from biomass burning are distributed, how that impacts on radiative budget and how it contributes to climate change in "Simulation of Distributions and Climate Impacts of Biomass Burning Aerosols."

Unfortunately, biomass burning in China is not included in this special issue, where much research on biomass

burning has been recently performed. An emissions inventory from open burning of forests, bush, woodlands and grasslands in China was studied by analyzing satellite data (Song *et al*., 2009). Agricultural waste burning in China is increasing due to an increase in crop residue burning of rice and wheat straws, and many hotspots have been observed by satellites, especially in the middle and south of China. Through a bottom-up approach, on the other hand, an emissions inventory was developed from field burning of crop residues such as rice straw, wheat straw, corn stover, etc. (Cao *et al*., 2008). A comprehensive study on emissions inventories including both agricultural and non-agricultural burning is expected in China.

More than twenty years ago in Japan, open burning of rice residue after harvest in autumn was common, affecting many people living in the surrounding areas through severe air pollution, because open burning occurred mostly on fine, calm days. As an alternative to open burning, local governments recommended the incorporation of rice straw into surface soils after harvest for maintaining soil fertility. The application of organic materials such as rice straw into soils resulted in higher emissions of methane, a notorious greenhouse gas, into the atmosphere. Accordingly, local governments then recommended farmers to incorporate rice straw shortly after harvest, or to incorporate composts made from rice crop residue, which produce more carbon dioxide than methane. These are among the techniques for reducing methane emissions in rice cultivation. Now, rice straw is anticipated as bio-fuel to be a new energy source for heat and/or power production.

Heavy air pollution from a large-scale forest fire during 1987/1988 in Indonesia, was transported to the Malay Peninsula, where it caused many people, especially school children, to suffer from ill health. This problem is called 'trans-boundary haze pollution in Southeast Asia.' Now, the impact of biomass burning on human health is becoming a serious problem for people directly suffering from heavy air pollution aroung the world.

It is well known that trace gas and aerosol emissions arise from biomass burning and contribute to climate change by both cooling and warming. The emissions ratio of each species from biomass burning to the total emissions is estimated to be in a range of 3%-46% (Tsuruta, 2004). Direct and indirect effects of aerosols on radiative forcing are estimated to be large, although the uncertainty in regard to them is also large, due to the complex behavior of cloud particles (IPCC, 2007). Hence, an emissions inventory of aerosols, including black carbon from biomass burning, will be crucial to reliable provisions for future climate change.

Analysis of biomass burning using satellite imagery is becoming more and more important, while there is still

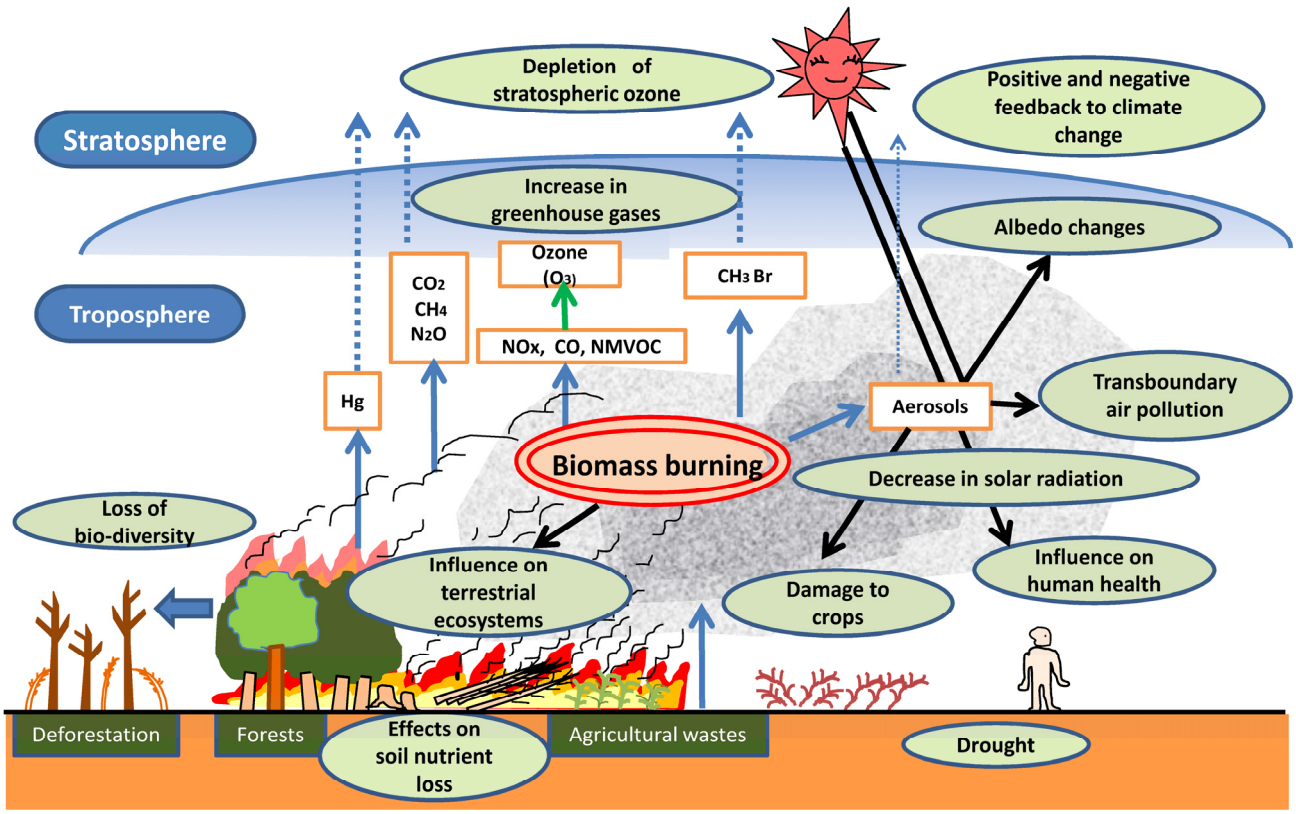

Fig. 1 Impacts of biomass burning on the Earth's environment. (Modified Tsuruta (2004))

uncertainty in comprehensive analysis. In addition, a bottom-up approach is expected also to be developed. The combination of both techniques could provide a comprehensive figure of biomass burning worldwide in the near future.

We are sure that this special issue will be greatly useful to researchers and administrators around the world for helping them understand the current situation of biomass burning, satellite data analysis and impacts on climate change.

Finally, we would like to express many thanks to all the authors and anonymous reviewers in this special issue. This special issue could not have been published without their great help and efforts, in particular because one of the editors has had to devote himself to urgent research and organization on the impact of radioactive substances on the environment, which have been released into the atmosphere due to the accident at the Fukushima Daiichi Nuclear Power Plant since March 2011. And we sincerely apologize for publishing this issue after much delay.

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References

Butchaiah, G., S. Bonnet, C. Menke and S. Garivait (2009) Air pollutant emissions from rice straw open field burning in India, Thailand and the Philippines. *Environmental Pollution,* 157(5): 1554-1558.

Cao, G.L., X.Y. Zhang, Y.Q. Wang and F.C. Zheng (2008) Estimation of emissions from field burning of crop straw in China. *Chinese Science Bulletin*, 53: 784-790.

The Fourth Assessment Report (AR4), Cambridge University Press, Cambridge. IPCC (2007) Climate Change 2007.

Song, Y., B. Liu, W. Miao, D. Chang and Y. Zhang (2009) Spatiotemporal variation in nonagricultural open fire emissions in China from 2000 to 2007. *Global Biogeochemical Cycles,* 23: GB2008.

Tsuruta, H. (2004) Impact of trace gases and aerosols emitted from biomass burning on atmospheric environment, watching of atmospheric environment from satellites, NASDA EORC 55-71. (in Japansese)