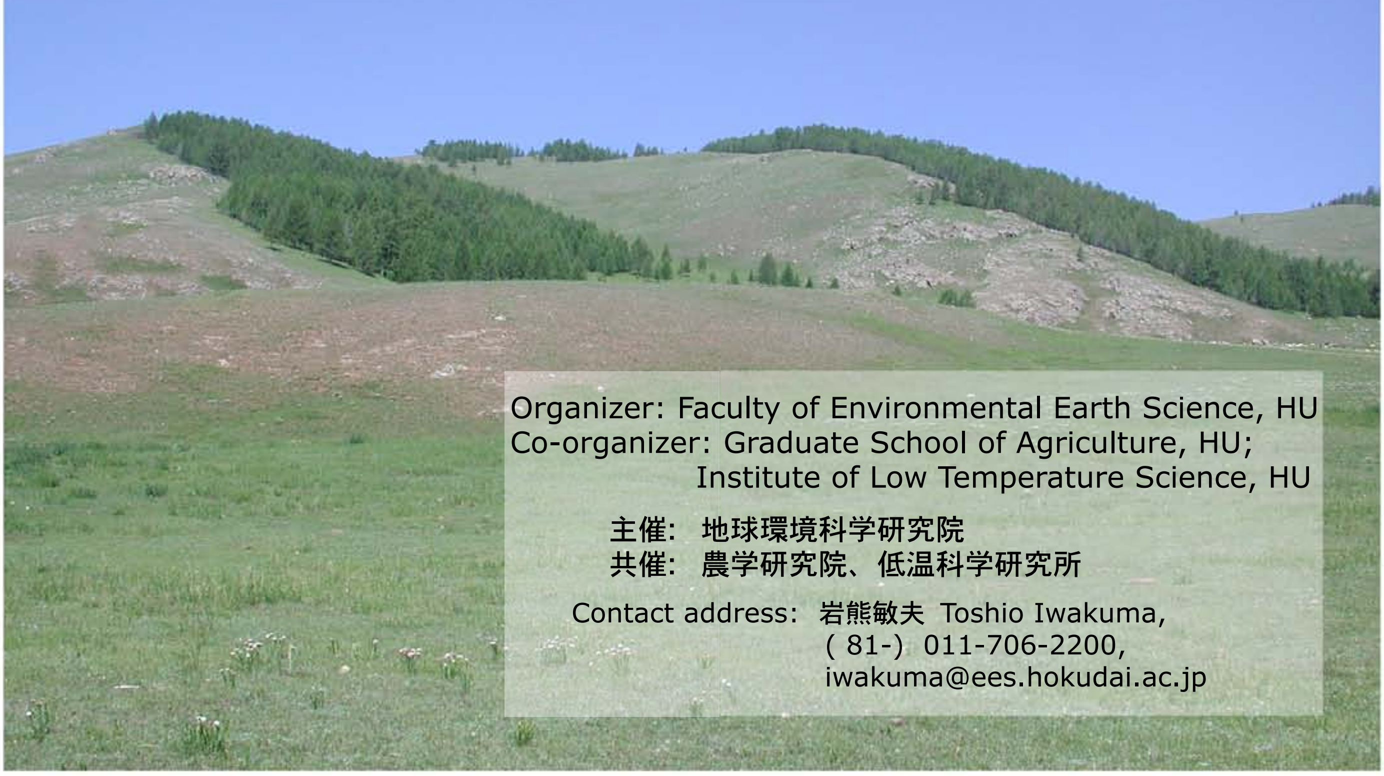
Environmental Monitoring for Conservation of Ecosystems

生態系保全のための環境モニタリング

12:00-17:30
Wednesday, 25 June 2008

Room No. 1, Conference Hall, Hokkaido University

北海道大学 学術交流会館 第一会議室



Organizer: Faculty of Environmental Earth Science, HU
Co-organizer: Graduate School of Agriculture, HU; Institute of Low Temperature Science, HU

主催: 地球環境科学研究院
共催: 農学研究院、低温科学研究所

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Environmental Monitoring for Conservation of Ecosystems

Extreme weather conditions observed globally have recently caused abnormal changes in ecosystems. To help understand the current situation and mechanisms of these abnormal changes to the Earth, the latest results of atmospheric, meteorological and hydrological observation and research at the South Pole as well as in tropical and temperate zones will be reported.

Opening session

Moderator: Toshio Iwakuma, Faculty of Environmental Earth Science, HU
12:00-12:10 Opening address
Akira Kouchi, Institute of Low Temperature Science, HU
12:10-12:50 Activities of Ministry of Education, Culture, Sports, Science and Technology on climate change and global warming
Naoko Okamura, Ministry of Education, Culture, Sports, Science and Technology

Plenary Lecture

Chair: Motoyoshi Ikeda, Faculty of Environmental Earth Science, HU
12:50-13:40 Hydrometeorological Array for ISV-Monsoon Automonitoring (HARIMAU)
Manabu D. Yamanaka, JAMSTEC/Kobe University

Invited Lecture 1

Chair: Yasushi Fujiyoshi, Institute of Low Temperature Science, HU
13:40-14:30 The Project of the Antarctic Syowa MST/IS Radar (PANSY)
Kaoru Sato, The University of Tokyo

14:30-14:50 Break

Invited Lectures 2

Chair/interpreter: Atsuko Sugimoto, Faculty of Environmental Earth Science, HU
14:50-15:40 The carbon budget of permafrost-dominated ecosystems
Trofim C. Maximov, Institute for Biological Problems of Cryolithozone, Siberian Branch of Russian Academy of Sciences

Invited Lectures 3

Chair/interpreter: Mamoru Ishikawa, Faculty of Environmental Earth Science, HU
15:40-16:30 Environmental and climate change in Mongolia
Azzaya Dolgorsuren, Institute of Meteorology and Hydrology, Mongolia

Invited Lectures 4

Chair: Mitsuru Osaki, Graduate School of Agriculture, HU
16:30-17:20 Carbon dioxide balances of tropical and temperate forests
Takashi Hirano, Graduate School of Agriculture, HU

17:20-17:30 Closing Remark
Toshio Iwakuma, Faculty of Environmental Earth Science, HU

生態系保全のための環境モニタリング

近年，全世界的な異常気象が地球の生態系に異変をもたらしています。地球の異変の現状とその仕組みについて理解を深めるため，南極，熱帯，温帯での大気や気象・水文などについて，最新の観測研究成果が報告されます。

開会セッション

司会：岩熊敏夫，北海道大学大学院地球環境科学研究院
12:00-12:10 開会の挨拶　香内晃，北海道大学低温科学研究所
12:10-12:50 気候変動・地球温暖化に対する文部科学省の取組
　岡村直子　文部科学省研究開発局海洋地球課地球・環境科学技術推進室

基調講演

座長：池田元美　北海道大学大学院地球環境科学研究院
12:50-13:40 社会的にも学術的にも貢献し得る地球観測を目指して:海大陸レーダーネットワーク構築（HARIMAU）
山中大学，JAMSTEC/神戸大学

招待講演１

座長：藤吉康志　北海道大学低温科学研究所
13:40-14:30　南極昭和基地大型大気レーダー計画（PANSY）
　佐藤薫　東京大学大学院理学系研究科

14:30-14:50　休憩

招待講演２
座長：杉本敦子　北海道大学大学院地球環境科学研究院
14:50-15:40　永久凍土帯生態系の炭素循環
　マキシモフ,トロフィーム、ロシア科学アカデミー　寒冷圏生物学研究所

招待講演３
座長：石川守　北海道大学大学院地球環境科学研究院
15:40-16:30　モンゴルにおける環境と気候の変化
　ドルゴルスレン，アザヤ、モンゴル国家水文気象研究所

招待講演４

座長：大崎満，北海道大学大学院農学研究院
16:30-17:20 熱帯と温帯における森林の炭素収支
　平野高司　北海道大学大学院農学研究院

17:20-17:30　閉会の挨拶
　岩熊敏夫　北海道大学大学院地球環境科学研究院

A new scientific scheme to promote social/academic benefits: Hydrometeorological ARray for Isv-Monsoon AUtomonitoring (HARIMAU)

Manabu D. Yamanaka
JAMSTEC-IORGC/Kobe University

The earth's global environment is the result of 4.5 billion-year history of interactions among the earth's surface, oceans, lives and atmosphere. All larger planets have atmospheres, but an ocean and an oxygen-rich atmosphere are known only on the earth even after planets out of the solar system have been discovered. In the ocean guarded from solar ultra-violet rays, organic materials were changed into lives, which led to the earth having the oxygen-rich atmosphere and the habitable land surface. We human beings appeared finally and spread over the lands, particularly in the east/south Asia (so-called "monsoon Asia") region with prominent seasonal variations. Therefore, to know climate changes and human-earth interactions in this special region is basic to understand the global environment, but there are still many areas out of observational coverage.

The human beings are lives doing sciences, which have been developed and expanded based on two motivations: intellectual/academic curiosity and survival/social benefit. In Asia population and economic capacity are approaching to the upper limit, and any scientific activities including climatological observations are requested to contribute not only to the science but also to the society. Since how the studies are promoted is equivalent to how the scientists and their institutions are surviving, two categories of institutions, the universities for small/basic sciences and the national institutes for big/applied sciences, must be coexistent with each other and the scientists may hold posts at the both categories.

At such a turning point of the history of the earth and the human beings, several observational projects for climate changes are being carried out. As an example, the radar network construction (the HARIMAU project) over the "maritime continent" (Indonesian Archipelago and surroundings) is introduced. Five radar stations are installed during 2006–8, and their data are displayed on the internet in real time. As a scientific result, on one hand, the reason why the earth's cloud activity is most active in the maritime continent is clarified as that a diurnal-cycle temperature/wind variation near the coastline is most effective to generate clouds in the equatorial region and the coastline is much longer in the maritime continent rather than in true continents. On the other hand, assessment and reduction of flood disasters having made millions of suffers every year are also successfully promoted, and such contribution of HARIMAU project has been nominated as an early achievement of the Global Earth Observation System of Systems (GEOSS).

社会的にも学術的にも貢献し得る地球観測を目指して:
海大陸レーダーネットワーク構築（HARIMAU）

山中 大学
海洋研究開発機構地球環境観測研究センター／
神戸大学大学院理学研究科

地球の現状は，45 億年にわたり地面と海と生物と大気とが互いに他を変えようとした歴史の結果である．大気は大きめの惑星には全て存在するが，液体の大気（海）や酸素を多く含む大気は，太陽系外の惑星が知られつつある今でも我が地球でしか確認されていない．太陽紫外線から守られた海中で有機物が生物となり，彼ら自らが大気成分の 2 割を酸素に変えて上陸を可能にした．我々人類はこの歴史の最後に生まれ気候変動と戦いつつ地球全陸地に広がったが，特に季節変化の顕著な東～南アジア（モンスーンアジア）に集中して生息している．この地域での気候変動や人類と地球とのやりとりを知ることが「地球環境」を知る基本であるが，観測は今なお空白が多い．

人類は科学する生物であり，科学は人類の知的好奇心（学術）および生存・繁栄（社会貢献）という二つの動機で進歩し巨大化してきた．人口や経済発展が限界に近づきつつあるアジアでは，研究活動は社会と学術との両面にバランスよく貢献することが強く求められており，気候変動観測も例外ではない．研究のあり方とは研究機関のあり方や研究者の生き方でもあり，大学と国家政策的研究機関法人とのバランスよい発展やそれら両方の兼務などが求められる所以である．

このような地球史・人類史の大きな曲がり角において進められている気候変動観測の一例として，「海大陸」域（インドネシア諸島とその周辺）での気象観測網構築（HARIMAU）計画を紹介させて頂く．2006 年秋から今年秋までに 5 つのレーダー観測点を建設し，そのデータはネット上で公開している．なぜ地球上の雲活動がこの海大陸で最も活発かの理由が，赤道域の雲は毎日の海陸温度差で最も効果的に作られ，ここが島嶼であるため大陸よりずっと長い海岸線を持つためであるということが解明された．同時に，百万人規模の被害者を生む水害のアセスメントや減災へ向けた試みも成功しつつあり，全地球観測計画（GEOSS）における初期成果の一つとして評価されている．

Program of the Antarctic Syowa MST/IS Radar

Kaoru Sato[1]; Masaki Tsutsumi[2]; Toru Sato[3]; Akinori Saito[3]; Yoshihiro Tomikawa[2];Koji Nishimura[2]; Hisao Yamagishi[2]; Takashi Yamanouchi[2]; Takehiko Aso[2]; Masaki Ejiri[2]
[1] The University of Tokyo; [2] National Institute of Polar Research;
[3] Kyoto University

Syowa Station is one of the distinguished stations where various atmospheric observations for research purposes by universities and institutes as well as operational observations by Japan Meteorological Agency and National Institure of Information and Communications Technology are performed continuously. National Institute of Polar Research plays a central part in the operations. The observation of the Antarctic atmosphere is important in two senses. First, it is easy to monitor weak signal of the earth climate change because contamination due to human activity is quite low. Second, there are various unique atmospheric phenomena in the Antarctic having strong signals such as katabatic flows, the ozone hole, noctilucent clouds, and auroras. The middle atmosphere is regarded as an important region to connect the troposphere and ionosphere. However, its observation is sparse and retarded in the Antarctic compared with the lower latitude regions; nevertheless the vertical coupling is especially important in the polar region.

Since 2000, we have developed an MST/IS radar which is operational in the Antarctic and have made feasibility studies including environmental tests at Syowa Station. Various significant problems have been already solved, such as treatment against low temperature and strong winds, energy saving, weight reduction, and efficient construction method. A current configuration of the planned system is a Doppler pulse radar with an active phased array consisting of 1045 yagis. As an activity of JARE49 (the 49th Japanese Antarctic Research Expedition) and JARE50, a pilot radar system which consists of newly developed antennas and T/R modules is being installed at Syowa Station, to know the overall performance of the radar system. This pilot system is being used for IPY (International Polar Year) 2007-2008 as a meteor radar to monitor winds in the lower thermosphere which are hard to be performed by existing observation facilities.

The value of the PANSY project has been approved internationally and domestically by resolution and recommendation from international scientific organizations such as IUGG, URSI, SPARC, SCOSTEP, and SCAR. The scientific research objectives and technical developments have been frequently discussed at international and domestic conferences and at a scientific meeting at NIPR organized by the PANSY group every year. In this fiscal year, we will summarize the results of these discussions and feasibility studies as a few booklets. Special sessions for PANSY will be also organized at related scientific societies such as MSJ and SGEPSS to deepen the discussion with an eye to submission of our proposal.

南極昭和基地大型大気レーダー計画（PANSY）

佐藤薫[1]；堤雅基[2]；佐藤亨[3]；齊藤昭則[4]；冨川喜弘[2]；西村耕司[2]；山岸久雄[2]；山内恭[2]；麻生武彦[2]；江尻全機[2]
[1] 東大院理；[2] 極地研；[3] 京大院情報；[4] 京大院理

南極昭和基地は，気象庁定常観測，極地研を中心とした各研究機関による大気研究観測が精力的に行なわれ，世界的に見ても数少ない総合大気観測拠点となっている．南極大気は人間活動から隔絶されているため，ノイズが小さく，地球気候のモニタリングに適しており，また，カタバ風や，オゾンホール，夜光雲，オーロラなど，顕著な（シグナルが大きい）大気現象が見られる領域でもある．しかしながら，下層大気と超高層大気をつなぐ中層大気の観測は手薄であり，上下結合がとりわけ重要な極域大気研究は他の緯度帯に比べれば，遅れているといわざるを得ない．

2000 年に始まった南極昭和基地大型大気レーダー計画（PANSY）では，この問題を克服し，既存の大気観測をつないで極域大気全体を統合的に捉えるため，南極で運用可能な大型大気レーダー（MST/IS レーダー）の開発およびフィージビリティスタディを行なって来た．南極での運用に必要となる、低温強風対策、低電力化、低重量化、設置作業の高効率化などの諸問題をほぼ全て解決した。現在、実現可能で科学的意義の高いシステム仕様として、アンテナ素子1045本からなるアクティブフェーズドアレイ方式のドップラーパルスレーダを考えている。49 次および50 次隊では、アンテナや送受信モジュールなどの新たな開発部を含むパイロットシステムを昭和基地にて設置し、総合試験を行なうべく作業を進めているところである。このパイロットシステムは、流星観測機能を備えており、これを用いて、昭和基地の既存の測器では観測が難しかった下部熱圏の高精度風観測も行なう予定である。

この計画の国内外の評価は高く，IUGG を初め，関連するほとんどの国際学術組織からの支持を得ている．PANSY研究グループでは，毎年極地研を中心に研究集会を開催し，適宜国内外の学会でも発表を行い、技術開発および科学目標について広く議論を積み重ねてきた.今年度は、概算要求に向けて、フィージビリティスタディの結果を報告書にまとめ、関連する学会において特別セッションを企画し、PANSY 科学的意義について議論を深める予定である。

The carbon cycle of permafrost-dominated ecosystems

Trofim Chr. Maximov

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Siberian Branch of Russian Academy of Sciences

This issue of carbon uptake of main Siberian permafrost forests and tundras has direct economic implications under the Kyoto Protocol. Not only can the uptake by permafrost ecosystems be used to counter industrial emission, but any surplus uptake capacity may be sold by emission trading. Large reservoirs of carbon have been accumulated in the ecosystems of this region over many centuries. We estimate that carbon stock in the soils of forest and tundra ecosystems of Yakutia is 17 *Gt C*.

The results of statistically reliable data on eddy-covariance (1996-2007), obtained at 12 stations, allowed us to quantitatively assess annual carbon fluxes in four representative biomes of the Russian Federation. It has been established that carbon sink significantly dominates in the permafrost forests of Yakutia compared to other investigated biomes of Russia. The sink here is greater than in the meadows and tundras of Russia by 1.5 and 4.5 times respectively. In total, all the territory of the Russian Federation is an area of considerable carbon sink equaling 1.9 $Gt\ C\ yr^{-1}$. Largest carbon sink belongs to forests, followed by meadows, and then come bogged territories.

永久凍土生態系の炭素循環

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シベリア永久凍土帯の森林とツンドラは、京都議定書のもと、経済的に重要な位置をしめる。産業により排出される二酸化炭素を永久凍土生態系が吸収するだけでなく、その二酸化炭素吸収能力が排出枠取引されうる。この地域には何世紀にもわたって生態系に炭素が蓄積してきた。その量は、我々の見積もりでは、ヤクーチア（サハ共和国）の森林とツンドラ生態系の土壌中に 17GtC **ある。**
ロシア国内の４つの代表的な植生帯において１２の観測サイトで得られた渦相関法によるフラックスデータ（1996-2007 **年）の結果から、定量的な解析が可能となった。そして、ヤクーチアの永久凍土帯の森林は、ロシア国内の他の植生帯に比べて、炭素の吸収量が多く、**meadow**、ツンドラのそれぞれ** 1.5 **倍、**4.5 **倍である。ロシア国内では、合計すると** 1.9GtC/**年の炭素吸収と見積もられる。吸収量は、森林、**meadow**、**bog **の順である。**

Environmental and Climate change in Mongolia

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Introduction

Mongolia is situated in the East Asia between Russia and China far from Oceans and Sea with a population of 2.8 million and territory of 1.566 million square km. The average altitude is 1580 m above the sea level and it is on average 1000 km distance from the nearest access to a sea. For that reason Mongolia has a continental climate with four distinct seasons. Mongolia is a specific country with sharp continental climate and small precipitation. Vast semi-arid (semi-desert) and Plains Mountains in the west and southwest the Gobi desert in south and southeast. 42.5 percent of Mongolian territory is occupied by the Gobi desert, covered by scattered and short plants, which grow on the semi-desert and Gobi steppe brown soil with weak fertility.

The extreme climate and geography as well as the landlocked condition greatly influence the Mongol's way of life. As far as Mongolia, where more than 40 percent of the population is engaged in livestock breeding, the life of people depends mostly on the weather and natural condition.

The ethic composition of Mongolia is fairly homogeneous: there are two national majorities representing different ethic groups and 15 national minorities representing different ethic groups. The density of the population is extremely low, only 1.7 persons per square km and still many areas remain virtually unpopulated.

Current situation of desertification and its change

Desertification and drought are very important issue in Mongolia, because 90% of Mongolian territory is located in semi-arid and arid regions. Mongolia has been affected by drought and desertification during the whole period of its history and development because of its affiliation with the capricious and semi-arid and arid zones with a shortage of moisture.

Table 1. Grade of desertification, Mongolia

Grade of desertification	**1990**	**2000**
Land with weak sign of desertification	760	34.9
Land with average sign of desertification	20.0	38.7
Land with strong sign of desertification	3.0	16.1
Land with severe sign of desertification	1.0	1.8
Desert land with drought	-	8.5
Territory covered by drought	41.3%	44.7%

Table 1 shows, that the territory, exposed to drought has increased by 3.4 percent in the 10 years between 1990-2000 and the square of land with strong sign of desertification has increased by 5.4 times, the land with severe sign of desertification has also increased by 1.8 times.

In 2000, the ecosystem of pasture land in the steppe area, which occupies 33.8 percent of Mongolian area, suffered from improper human activities and 11.6 percent of them suffered very strong, 2.0 percent of the territory was damaged strongly.

In Mongolia 70 percent (126.6 million hectares) of rangeland have been deteriorated at a certain extent and the biomass of grassland was decreased by several times. Therefore, certain part (25 million heads) of livestock has been deprived of fodder, which reduces the number of cattle and their productivity.

In the last years 40 percent of forestland, which covers only 8 percent of Mongolian territory, have suffered badly because of improper human activities and the reserve of forestland has been reduced from year to year as the result of this improper human activities, harmful insects, forest fires and etc.

Local people in the Gobi desert area have cut the saxaul trees, which are principal plant of the Gobi desert area, more frequently as firewood for many years and thus the saxauls of 125.0 thousand hectares of land were exterminated completely. But still the inhabitants of aimag and soum centers in the Gobi desert area use various trees and bushes as firewood.

As a result of climate changes, the process of desertification has increased and the repetition of various natural calamity phenomena has been demonstrated by snow melting in the mountain caps, river drying, bad growth and development of grasses, the soil water salting, degradation and erosion of soils and the loss of its humus and fertility, and the increase of sand move.

Recently in the country 647.0 thousand square km or 41.3% of total area is affected by sand, especially in the Govi desert area. The size of area, which is covered by sand has increased (with 38000 hectares) during the last 30 years.

Besides the natural factors, the multi-sided human activities have shown negative effect in the increasing trend of desertification. In the early 1990s, due to the privatization of livestock head of private livestock increased by overloading and crumpling the pasture. According to the above mentioned traditions of pastoral livestock breeding have been lost and these factors are became one of the key reasons of desertification.

Current situation of permafrost and its change

Permafrost underlies approximately 63% of Mongolia area, which is located higher than 43°N. Mongolia has 7 kinds of permafrost: continuous, discontinuous, widespread, rare spread, sporadic, pereletka and seasonal.

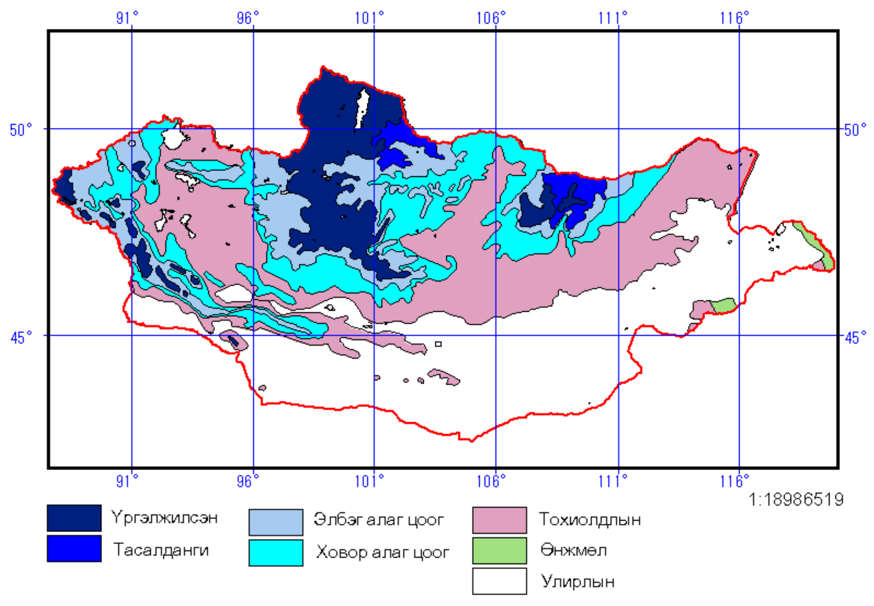

Fig 1. Distribution of permafrost in Mongolia by Dr.Tumurbaatar.D. (1968-1970)

Continuous permafrost underlies 141000 square km, which is 9.4% of the territory. This kind of permafrost mostly distributed in the valleys of Khangai, Khuvsgul and Altai mountains. In this region depth of permafrost is 100-200 meters, the maximum reaches 500 meters. Average temperature of the permafrost is –1.5 degrees and the maximum –3.5 degrees.

Discontinuous permafrost underlies 27000 square km, which is 1.8% of total area and distributed in the valleys of Khentii, Eastern Khuvsgul and Altai mountains.Widespread permafrost underlies 152630 square km, which is 10.2% of Mongolian territory. The distribution of this permafrost starts from 1460-1800 meters. Its depth is 50-100 meters. The mean temperature of this permafrost is –1.0 degrees and the maximum reaches –1.5 degrees. Rare spread permafrost underlies 190930 square km, which is 12.2% of territory of the country. Depth of this permafrost is mostly 10-50 meters. Temperature of the permafrost is –0.5 degrees and the maximum –1.0 degree.

Sporadic permafrost underlies 460110 square km, which is 29.4% of territory. This kind of permafrost mostly distributed in the valleys of the central part of country, Orkhon-Selenge river basin, Great lakes depression and the Northern part of Eastern Mongolia. Depth of this permafrost is mostly 5 meters. Temperature of the permafrost is –0.1 degrees and the maximum –0.5 degrees [D.Tumurbaatar, IG, MAS, Mongolia]. Pereletka permafrost forms in the Eastern Mongolia, depending on winter condition, temperature and snow cover. If snow cover is not depth, then it forms.

Seasonal permafrost forms in the Southern part of steppe region and Govi area, where soil freezing depth is from 1.7 meters to 3.5 meters. Results of scenario of climate change HADCM3 model, version A2 of CO_2 concentration show that continuous permafrost in Mongolia will decrease by 4.4% in years 2010-2039, by 0.5% in years 2040-2069 and will be not much permafrost in years 2070-2099, such as without permafrost area will increase by 71-80% and only discontinuous, widespread, rare spread, sporadic permafrost area will remain in the valleys of Khuvsgul, Khangai and Khentii mountains [T.Ganbaatar, IMH, Mongolia].

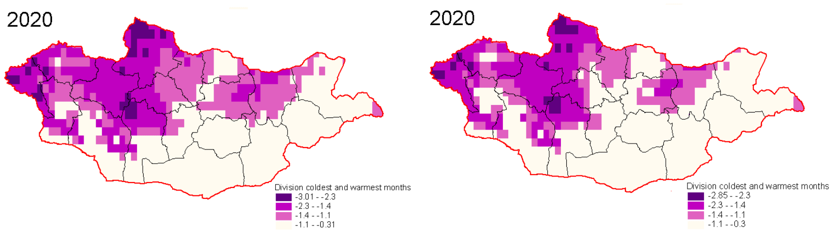

Fig 2. Ratio $F_{jan/jul}$ or distribution of permafrost by versions A2 and B2 of HadCM3 model for years 2010-2039

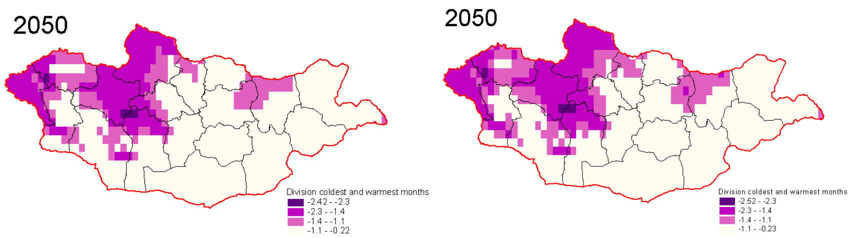

Fig 3. Ratio $F_{jan/jul}$ or permafrost distribution computed by versions A2 and B2 of HadCM3 model for years 2040-2069

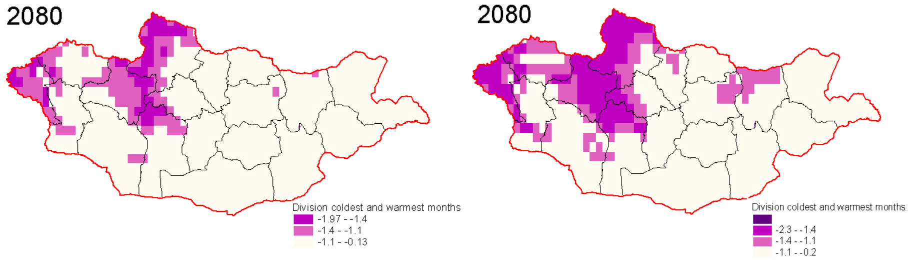

Fig 4. Ratio $F_{jan/jul}$ or permafrost distribution computed by versions A2 and B2 of HadCM3 model for years 2070-2099

Climate and its change

The annual average air temperature in Mongolia has increased in the last 65 years by 1.9 degree Celsius and in a winter by 3.6 degrees, in a spring and autumn by 1.4-1.9 degrees and it has decreased in a summer by 0.6 degrees. According to this the duration of non-frosted period has increased also by 10-19 days. If take the regions of Mongolia, then in the southern and eastern parts of Mongolia annual average air temperature has increased by 1.5-1.6, in the western and central regions by 2.0-2.3 [P.Gomboluudev, IMH, Mongolia].

Precipitation amount for a year in the country various from 300 to 400 mm. Annual precipitation has decreased in the Central and Gobi regions of Mongolia by 8.7-12.5%. It has increased in the Eastern and western regions by 3.5-9.3%. Annual precipitation amount has increased in autumn and winter by 5.2-10.7%. It has decreased in the spring and summer. Amount of precipitation for the growing period (May-September) has decreased and precipitation amount of the cold period (November-March) has increased by 5%. Wind speed has increased by 0.03 m/s.

There is significant change in land cover due to an increasing of anthropogenic forcing, such as desertification and deforestation may affect climate by changing the hydrological cycle and surface energy balance.

Weather extremes are very important key issues in Mongolia. Before 1990s Mongolia had 25-30 weather extremes in a year, recently it has increased until 40-60 and sometimes it reaches 81. 41% of total weather extremes are dust and snow storms, 29% - rainfall and thunderstorms, 18%- heavy rain and snow and others are like dzud (very harsh winter), drought, forest & steppe fire and flood [L.Natsagdorj, IMH, Mongolia].

Drought, covering 25 percent of Mongolia's territory has been happening once in every 2-3 years and the drought, which covers 50 percent of the country, has been happening once in every 4 to 5 years. The number of days with dust and sandstorms in the steppe and Gobi desert zones has increased by 3 and 4 times by the beginning of the 21st Century in comparison with 1960's. Drought occurred >50% of Mongolian area has been happened 4 cases in a decade (10 years) for the period 1941-1950 and 1981-1990, 3 cases for the period 1991-2000, 1 or 2 cases in a decade for the period 1961-1970 and 1971-1980. Since 2000 drought is more frequent. Mongolia has the drought in years 2000, 2001, 2002, 2005 and 2007. High drought occurrence is in the Gobi desert area and it occurs once in 2-3 years) [J.Tsogt, IMH, Mongolia].

Mongolia has 1.3 million hectares of arable land that can produce environmentally clean and friendly products. Due to climate change almost half million hectares of land has eroded, which has been used for agriculture during the last more than 40 years. Also 70% of Mongolian area is degraded. The yield from severely degraded pasture has decreased by 5 times.

Conclusion

1. Mongolia is warming and becoming drier from year to year.
2. Following the climate change environment in Mongolia will be having some changes, such as desertification.
3. According to this warming frequency of weather extremes is increasing and it will increase in the future. Weather extremes are more severe and carry lot of damages and losses.
4. Due to change of the meteorological elements in the last years permafrost area is decreasing and it will be continue in the future.

モンゴルにおける環境と気候の変化

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モンゴルでの主要な産業は遊牧であり、これにより乾燥気候環境下での乏しい生態系サービスを持続的に利用できる。したがって、砂漠化と旱魃は生活基盤を脅かす深刻な災害であるが、近年旱魃の危険に晒される地域の増加や、草原バイオマス量の減少などが顕在化している。人為圧も土地劣化に大きく関与しており、違法伐採、虫害、火災などによる森林衰退が著しい。ゴビ砂漠では、住民により低木が皆伐され、過去 30 年間で 3.8kha が砂漠に変わった。1990 年代初めに家畜が私有化され、このことにより家畜の増加、過放牧が砂漠化に拍車をかけている。

モンゴルはユーラシア永久凍土帯の南限に位置する。気候モデル実験は、永久凍土の分布域は 2039 年までに現状から 4.4%減少し、2099 年までには一部の山岳地域に限られるようになることを予測している。

モンゴルでは過去65年間で1.9℃年平均気温が上昇した。季節毎にみると、冬季は3.6℃、春季と秋季は 1.4 -1.9℃、夏季には 0.6℃温暖化している。年降水量は 300 -400㎜ 程度であるが、秋季や冬季の降水量は増加しているが、草原植生の成長期に相当する春季や夏季の降水量が減少している。

1990 年以前、年間の気象災害は 25 -30 回程度であったが、近年では 40 -60 回、時には 80 回を超えることもある。砂嵐、吹雪、豪雨、豪雪、ゾド、旱魃、森林・草原火災、洪水などの頻度が増している。なかでも旱魃は頻発しており、国土の 25%では 2 -3 年毎に、50%では 4 -5 年毎におきている。最近では 2000、2001、2002、2005 年と立て続けに旱魃に見舞われた。モンゴルでは 130 万ヘクタールの耕作に適した土地があるが、気象災害により耕作地の約 50 万ヘクタールが侵食され、その機能を失っている。

Carbon dioxide balances of tropical and temperate forests

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Terrestrial ecosystems function as a large carbon sink as a whole in the global carbon balance. The carbon balance of individual ecosystem varies temporally and spatially, depending on endogenous factors and the environment. To investigate vegetation functions for the global carbon cycles, the carbon dioxide (CO_2) exchange of terrestrial ecosystems with the atmosphere (CO_2 flux) has been measured since the mid-1990's using the eddy covariance technique over various ecosystems.

We have measured CO_2 flux above tropical peat swamp forests in Central Kalimantan, Indonesia since 2001 and a larch forest in Hokkaido, Japan since 2000. The former forests are growing on tropical peatlands with different disturbance levels: an undisturbed evergreen swamp forest, a drained swamp forest and a drained cutover. Peat swamp forest was deforested and drained to develop farmland on a large scale in this area during the 1990's. Although peat swamp forest occupies a small portion of the total area of tropical forest, it has become a great concern of not only researchers but also policymakers from the viewpoint of carbon balance, because underling tropical peat stores huge carbon as soil organic matter. Recently, the carbon pool in tropical peat has become more vulnerable and has a high potential to switch to a large carbon source in the near future under the conditions of climate change and large-scale disturbances by human activities, such as land-use change and fires.

The latter forest is a larch plantation established in the mid-1950's. Larch forest is widely distributed over temperate and boreal regions in East Asia. The larch plantation, however, was seriously destroyed by strong wind from a typhoon in 2004. Typhoon is an important disturbance factor for forest ecosystems in East Asia, which are damaged extensively and intensively. CO_2 flux has been continuously measured even after the typhoon disturbance.

I will mainly talk about the CO_2 balance of the tropical peat swamp forests and the larch forest as the representative of tropical and temperate forests, respectively, using our data. Topics include seasonal variations, interannual variations, controlling factors and disturbance effects.

熱帯と温帯における森林の炭素収支

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陸域生態系は，地球規模の炭素収支において大きな炭素シンクである。個々の生態系の炭素収支は，生態系の内的要因と環境条件に依存し，時空間的に変動する。地球規模での炭素循環に対する生態系の機能を明らかにするために，1990 年代半ば以降，様々な生態系において，生態系と大気との間の二酸化炭素（CO_2）交換速度（CO_2 フラックス）の渦相関法による連続観測が行われるようになってきた。

われわれは，インドネシア中央カリマンタンの熱帯泥炭林と北海道のカラマツ林において，それぞれ 2001 年，2000 年から CO_2 フラックスの観測を継続している。熱帯泥炭林は熱帯泥炭の上に発達する森林で，人為撹乱の程度の異なる 3 つのサイト（未撹乱の自然林，排水された自然林，排水された伐採跡地）で観測を行っている。この地域の熱帯泥炭林は，農地開発を目的として 1990 年代に大規模開発（排水，伐採）された。熱帯林のなかで熱帯泥炭林の占める面積は小さいが，熱帯泥炭には土壌有機物として大量の炭素が蓄えられているため，炭素収支という観点から大きな注目を集めている。最近では，気候変動や人為的な大規模撹乱（土地利用変化や火災）のために熱帯泥炭の炭素の脆弱性が高まってきており，近い将来には巨大な炭素ソースとなる危険性がある。

カラマツ林は，東アジアの温帯域から寒帯域に広く分布する主要な陸域生態系である。研究対象のカラマツ林は，1950 年代半ばに造成された人工林であるが，2004 年に台風による大きな風倒被害を受けた。台風は東アジアにおける重要な自然災害要因であり，森林が大規模に被害を受けることが多い。風倒害後も，現地において CO_2 フラックスの観測を継続している。

今回は，観測データを用い，熱帯泥炭林とカラマツ林を中心にして熱帯林と温帯林の CO_2 収支について話をする予定である。また，CO_2 収支の季節変化，年次変動，制限要因，および CO_2 収支に与える環境撹乱の影響についても述べたい。