Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

MIS03-01 Room:101B Time:May 25 09:00-09:15

Progresses of MAIRS Dryland Study in East Asia

AI, Likun[1*]

[1]022271

Monsoon Asia Integrated Regional Study (MAIRS) is an international climate change research program which is focused on integration between physical and social sciences. Asian dryland region includes the large area of arid and semi-arid regions in east Asia and south Asia where is much vulnerable to climate change and human perturbation. In the same time, semi arid East Asian region is the northern of monsoon system. In MAIRS science plan, research questions are addressed as follows:

a, How does global warming affect the regional climate, water cycle, aridity trend, desertification processes and provision of ecological goods and services over semi-arid Asia?
b, How do human-induced land cover changes affect the regional climate, water conservation and nutrient-content of the soil, land degradation, the structure and function of terrestrial ecosystems and the frequency of dust storms?
c, What will be the global consequence of changing the long distance transport of dust aerosols, such as the carbon cycle in oceans?
d, What are the social and economic consequences of the further deterioration of semi-arid environmental systems, such as concerns related to human health, food and water security and economic development? How does human society adapt to such changes in vulnerability in order to achieve sustainable development of the region?

By now, MAIRS Dryland Study is structured into 4 task teams: Climate change dynamics; dryland observation; land surface modeling; coupled human-environment systems.

1) climate change dynamics
The study of climate dynamics would recognize the role of large-scale climate variations and changes as drivers of the natural and human systems in the dryland areas of monsoon Asia.
2) Dryland coordinated observation network
The MAIRS observation activities would help focus and enhance the various observation programs being carried out across the dryland areas of monsoon Asia. A major role of MAIRS is to synthesize the results from these activities to provide a foundation for the activities on natural and human systems.
3) Asian Dryland Models Inter-comparison Project
The goal of this group is evaluating and improving land surface models (LSMs, energy and water) & terrestrial ecosystem model (TEMs, carbon) through offline model intercomparison using data obtained at Asian dryland, towards better reproduction and prediction of landsurface state using improved models, and necessary capacity building.
4) Coupled Human-Environment systems
The main objective of this group is to incorporate resilience concepts into climate response and sustainable development strategies in the dryland systems of the Asian steppe by enhanced stakeholder involvement across a multiple set of decision makers from local pastoralists to policy makers in the national government

Keywords: dryland, climate change, East Asia, integration, adaptation

Japan Geoscience Union Meeting 2012
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MIS03-02 Room:101B Time:May 25 09:15-09:30

Challenges for Managing Rangelands under Changing Climate in Arid Regions

QI, Jiaguo[1*], Dennis Ojima[2], Chuluun Togtohyn[3], Jiquan Chen[4], Lyubov Lebed[5], Phil Heilman[6]

[1]Michigan State University, East Lansing, MI 48823, USA, [2]Colorado State University, Fort Collins , CO 80523, USA, [3]National University of Mongolia, Mongolia, [4]University of Toledo, Toledo, OH 43606, USA, [5]Kazakh Research Institute for Ecology and Climate, Almaty, Kazakhstan, [6]USDA-ARS Southwest Watershed Research Center, Tucson, AZ 85719, USA

Realizing that human activities are responsible for the continued global climate change that threatens societal sustainability, it is critically important that humans adapt strategies that allow a transition from a parasitic past to a commensal and ideally to a mutualistic future, in order to survive and thrive. The grand challenge facing humanity is to develop and implement viable and practical adaptation strategies and plans. This requires knowledge of how natural and human systems are coupled and how the components of each system interact. Acquisition of that knowledge requires the integrated study of human societies, ecosystem services and functions, and climate change, which can inform the development of effective adaptation strategies and policy implementation. Dryland ecosystems are sensitive and therefore vulnerable to climate change but nations primarily relying on rangelands ecosystem services are often least prepared for risks associated with extreme climate events. In this presentation, examples from different dryland case studies will be presented to highlight the challenges and effective management practices. The lessons learned from these case studies suggest that a system approach need to be developed to holistically mainstream climate concerns into development and management plans and strategies. The questions remained include how to scale up from local findings to national or regional levels. Although it is well-known that coupled human and environment systems vary with spatial and temporal scales, most of our basic scientific knowledge comes from small spatial studies conducted over short time periods. There is a critical need to conduct systems-oriented research on Coupled Human and Environmental MacroSystems (CHEMS) in order to understand and forecast the consequences of climate, land use and socioeconomics at regional to continental scales. Based on our CHEM concept, this synthesis paper aims at elucidating key commonalities in environmental sustainability across selected regional and continental scales.

Keywords: Dryland, Climate Change, Adapation, Rangelands, Coupled Human-Environment

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MIS03-03 Room:101B Time:May 25 09:30-09:45

Temporal-spatial Characteristics of Surface Dry/Wet status in Northeast China by NCAR/CLM3.5

TU, Gang[1*], Liu Bo[2], Wang Shuyu[3]

[1]Laboratory of Research for Middle-High Latitude Circulation system and East Asian Monsoon, Institute, [2]National Climate Center, Beijing 100081, China, [3]School of Atmospheric Science, Nanjing University, Nanjing 210093, China, [4]START Regional Center for Temperate East Asia and Key Laboratory of Regional Climate-Environment for

Long term (1951-2006) Surface Water Surplus (SWS) for growing season (May to September) over Northeast China is produced by NCAR CLM3.5, which is driven by daily observations from 102 meteorological stations. Temporal-spatial variability of surface dry/wet status is analyzed based on the CLM3.5 simulation. The results show that, 1) for growing seasons, 30 year (1971-2000) averaged SWS has relatively large spatial difference, with regional SWS ranging from 100 to 800mm. Higher SWS value locates over eastern, southern and northern parts of analysis domain, indicating a wetter condition over the area. 2) Significant inter-annual and decadalvariabilities are detected in CLM3.5 results; 3) Over Northeast China the SWS has decline trend showing that the surface has been drying during past 50 years. The drying signal is also found in decadal variance of spatial distribution of SWS, and with 2000s showing most dramatic drying, it implies that in the condition of global warming the aridification over Northeast China would enhance; 4) The surface moisture condition is the combined effects of land surface process and climate change; its prediction requires the thorough understanding of surface water budget.

Keywords: Northeast China, land surface, dry/wet status, land surface model, surface water surplus

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MIS03-04 Room:101B Time:May 25 09:45-10:00

Treeline dynamics under the climate changes in the Russian Altai Mountains

SYROMYATINA, Margarita[1*], Igor Moskalenko[1], Kirill Chistyakov[1], Maryam Kolunchukova[1]

[1]Saint-Petersburg State University

This research is a part of a big project of the Saint-Petersburg State University (SPbSU) - The Northern Eurasia mountain geosystems under the global climate changes and the transformation of the nature management regimes. The mountain regions, and particularly the Altai Mountains, are of specific interest due to the relatively low anthropogenic load and great sensitivity of the mountain landscapes. The current research is a continuation of the long-term field expeditions and theoretical researches of the SPbSU in the Altai-Sayan Mountains. The Department of Geography and Geoecology of the SPbSU has been organizing annual field expeditions to this mountain system during the last 20 years.

The regional climate changes are presented against the background of global climate change including the atmospheric circulation epochs. The uniqueness of the Altai landscapes lies in a great variety as the mountains are higher than 4 km and located on the zonal border between steppes and semi-deserts and between continental and sharply continental climates. The purpose of the research was to reveal space-time features of regional climate changes and the reaction of treeline position to these changes.

The 1940-2004 time series of the seasonal air temperature and precipitation from 14 weather stations from 300 to 2600 m a.s.l. were statistically analyzed applying regression, correlation, spectral and cluster analyses. The analysis of climate change spatial patterns in the region was made. To extend the time series over the past 350-400 years, mean summer temperature and precipitation were reconstructed applying dendroclimatological methods and using the WSL Dendro data base and core samples and tree line position estimates received during the field expeditions.

Comparing to the Northern Hemisphere the tendency of temperature increase in the second half of the 20th century over the Altai has been observed generally earlier, since 1950s. The most intense temperature increase during the last 20-30 years is specific to the most arid part of the region - South-Eastern Altai. Maximum warming rate in the last quarter of the 20th century is typical to winter in the Altai (0,85 degrees Celsius/10 years) as well as the entire Northern Hemisphere. Synchronous changes in the Altai and the entire Northern Hemisphere are observed in all seasons only in 1975-2004 years. At the turn of the XX-XXI centuries warming rates slow down in the region while the temperature level is still high.

The dendrochronological reconstruction showed that mean summer temperature increased from the end of the LIA to its maximum in the 1990s by approximately 2 degrees Celsius, to the average for the period 1986-2004 yrs ? about 1,3 degrees Celsius. Finally the climatic conditionality of the altitudinal belt spatial distribution, treeline and glaciers dynamics were estimated. In the Altai almost the full range of the temperate zone altitudinal belts is presented - from desert steppe to glacial-nival. Vertical hydrothermal gradients were employed to characterize each altitudinal belt by the climatic area of distribution (mean summer temperature and annual precipitation ranges). As treeline against the other belt borders strongly limited by summer temperature (7.5-9 degrees Celsius) its eventual dynamics were estimated and treeline position at different stages of warming was reconstructed. Theoretical evaluation shows that mean summer temperature increase of 1.3 degrees Celsius from the end of the LIA (1860-1880 yrs) to the period of 1986-2004 yrs causes treeline to rise maximum by 180-280 m in different localities of the Altai Mountains.

The results of the research are used for the development of the mountain landscapes dynamics prediction, the strategy of the mountain regions sustainable development and the estimation of the natural resources potential of the mountain landscapes.

Keywords: treeline dynamics, regional climate change, the Altai Mountains

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MIS03-05 Room:101B Time:May 25 10:00-10:15

Northern Eurasia Earth Science Partnership Initiative in 2011-2012: An Update

GROISMAN, Pavel[1*]

[1]UCAR at NOAA/NCDC, Asheville, NC, USA

Six years ago the Northern Eurasia Earth Science Partnership Initiative (NEESPI) was launched with the release of its Science Plan (http://neespi.org). Gradually, the Initiative was joined by numerous international projects launched in EU, Russia, the United States, Canada, Japan, and China. Throughout its duration, NEESPI served and is serving as an umbrella for more than 140 individual research projects (always with an international participation) with an annual budget close to 15 million US dollars. Currently, the Initiative is in full swing. A new crop of NEESPI projects was launched in 2010 and 2011 to compensate for the projects that have been completed and the total number of the ongoing NEESPI projects changed but slightly compared to its peak (87 in 2008). Since 2008, NEESPI has been receiving an intergovernmental level of support in Russia, the United States, and Ukraine.

The past year was extremely productive in the NEESPI outreach. In 2011, more than 100 peer-reviewed papers and/or book chapters were published or are in press (this list is still incomplete and is anticipated to nearly double). A suite of 25 NEESPI articles has been submitted and is currently in a peer review (4 of them), published and or accepted for publication (21 of them) for the Forth Special NEESPI Issue in *Environmental Research Letters* (19 in volume 6 and residual in volume 7 of the journal). Several books and White Papers were published by Springer (Baltzer ed., 2010; Gutman and Reissell, eds., 2011), and the National Academy of Science of Ukraine (Lyalko and Groisman, eds., 2012, in press in English, ”Naukova Dumka” Publ. House), and FAO (Matyas, ed., 2010). One more book devoted to Siberia was prepared by the members of the NEESPI team and is scheduled to appear before the end of this year (”Springer” Publ. House). Preparations have been started to complete the circle of regional monographs on Environmental Changes in the NEESPI domain with a book focusing on the dry land areas of Northern Eurasia.

The description of the NEESPI Program will be complemented with an overview of the results presented in book *”Regional Environmental Changes in Siberia and Their Global Consequences”*.

Keywords: NEESPI, Environmental change, Climatic change, Feedbacks to global climate

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MIS03-06 Room:101B Time:May 25 10:45-11:00

Temporal and spatial variations of atmospheric carbon dioxide and methane over Siberia

MACHIDA, Toshinobu[1*], ARSHINOV, Mikhail[2], BELAN, Boris[2], FEDOSEEV, Nikolai[3], MITIN, Sergey[4], SASAKAWA, Motoki[1], MAKSYUTOV, Shamil[1]

[1]National Institute for Environmental Studies, [2]V.E. Zuev Institute of Atmospheric Optics, [3]Permafrost Institute, [4]Institute of Microbiology

For a better understanding of the role of the terrestrial ecosystems in the global carbon cycle, atmospheric carbon dioxide (CO_2) and methane (CH_4) mixing ratios have been observed by air sampling method using aircraft over the wetland region near Surgut (61N, 73E) since 1993, over the forest/cultivated area near Novosibirsk (55N, 83E) since 1997 and over the forest area near Yakutsk (62N, 130E) since 1996.

Extremely large seasonal CO_2 variations were seen at 1km over Surgut with peak-to-peak amplitude of 22.0 ppm, whereas the amplitude at 7km was 10.7 ppm. Clear delay of summer minimum was found in seasonal variations, the difference being about half month between 1km and 7km. Steep negative gradients were observed in July and August with the difference in CO_2 mixing ratios between 0.5km and 7km of 6.9 ppm in July and 6.3 ppm in August. On the other hand, positive gradients were seen from November to April, suggesting that steady CO_2 emission was exist even in cold season in Siberia. The CO_2 increase over Surgut was only 0.3 ppm/year in 2010 but was returned to 1.2 ppm/year in 2011. The averaged growth rate of CO_2 from 1993 to 2011 over Surgut was 1.9 ppm/year.

The seasonal variations of CH_4 over Surgut were large at lower altitudes and no clear seasonal variations were observed in upper troposphere. At the altitudes of 0.5 km and 1 km over the western Siberia, maximum concentration was observed both in summer and winter. On the other hand, minimum concentrations were observed in summer at lower altitudes over Yakutsk. Observed high CH_4 in summer season was mainly resulted in CH_4 release from the wetland. Vertical differences in annual mean CH_4 between 7 and 0.5 km are 60 ppb over Novosibirsk and 85 ppb over Surgut, suggesting that large amount of CH_4 was released at ground surface especially from wetland near Surgut. Long-term trends of CH_4 observed over Siberia show rapid increase from 1997 to 1988 and stabilization after that. Siberian CH_4 started to increase again from 2007. At the altitude of 1 km, atmospheric CH_4 levels were highest over Surgut within 3 sites in Siberia, reflecting the strength of CH_4 emission around the observed area.

Keywords: CO_2, CH_4, aircraft, Siberia, carbon cycle, wetland

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MIS03-07 Room:101B Time:May 25 11:00-11:15

Megafauna and frozen soil: the drivers of atmospheric CH4 and CO2 dynamics

ZIMOV, Sergey[1*]

[1]North-East Scientific Station, Russian Academy of Sciences

In the late Pleistocene grass-herb communities dominated on the planet. Resting on permafrost Mammoth steppe was the biggest biome. It was a high productive ecosystem. Analyses of skeleton density in the permafrost of Northern Siberia have indicated that in Mammoth steppe animals biomass was ˜10 ton/km2 ? same as in African savannah. Soils of this ecosystem are rich with carbon.

Analysis of global 14C data for basal peat and modeling of the atmospheric methane isotope composition allowed us to reconstruct the dynamics of main global methane sources from late Pleistocene to present day. Only in the Holocene wetlands were the largest methane source .While during the glacial the largest source was mega herbivores whose total biomass exceeded the biomass of present-day humans and domestic animals. During deglaciation the largest methane emission was from degrading frozen soils of mammoth steppe biome. Besides methane these soils released ˜2500 Pg of carbon as CO2. Roughly 1,100 Pg of this carbon was taken up by forests and peatlands, while the oceans DIC and bottom sediments reservoirs consumed ˜1200 Gt. This reduced average carbonate ion concentration in the ocean by ˜20 mmol/kg. Ocean level rise during deglaciation led to increase of pressure in bottom sediments, this terminated carbon emissions from strongly 13C-depleted gas clathrates reservoir.

Pasture ecosystems have high albedo (especially in the snow season) and cool soils. Restoration of pasture ecosystems would slow thawing of permafrost and moderate climate warming.

Keywords: carbon cycle, permafrost, mammoth ecosystem, methane budget

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MIS03-08 Room:101B Time:May 25 11:15-11:30

Research on high-latitude Eurasian-global linkages at the International Arctic Research Center

WALSH, John[1*], Larry Hinzman[1]

[1]IARC, University of Alaska, Fairbanks

Research at the International Arctic Research Center/University of Alaska is addressing Eurasian-global connections through several avenues of research. First, the impact of increasingly warm pulses of Atlantic water on the Eurasian sector of the Arctic Ocean, including its sea ice, has been documented with data obtained during a series of cruises in the Siberian seas. The loss of sea ice in these seas has implications for the atmospheric heat budget and teleconnections to lower latitudes. Second, surface fluxes of trace gases, particularly methane, from the shelf seas north of Siberia has been found to be surprisingly large and possibly linked to degradation of subsea permafrost. The stores of methane in the Siberian shelf have the potential to be significant additions to the global atmospheric methane budget. Finally, changes in the subsurface temperatures of the major northern Eurasian river basins have been tied to changes in precipitation, particularly winter snow cover, which is driven by interannual and decadal variations of the atmospheric circulation.

Keywords: northern Eurasia, sea ice, methane, permafrost, snow cover

Japan Geoscience Union Meeting 2012
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MIS03-09 Room:101B Time:May 25 11:30-11:45

Age estimation of permafrost groundwater in Eastern Siberia

HIYAMA, Tetsuya[1*], ASAI, Kazuyoshi[2], Alexander Kolesnikov[3], Leonid Gagarin[3], Victor Shepelev[3]

[1]RIHN, Japan, [2]Geo-Science Laboratory, Japan, [3]Melnikov Permafrost Institute, Russia

Changes in water environment and hydrological cycle in permafrost region are very crucial issues in current global warming. Better understanding of groundwater dynamics in permafrost region is necessary for vulnerability assessment to the changing climate. Recent researches focusing on Eurasian Arctic Rivers reported that discharge from those rivers might be sensitive to climate warming primarily as a result of the melting of ground ice, because positive streamflow trends might exceed precipitation trends in magnitude around the Russian Arctic region. It was demonstrated that permafrost most likely plays a key role in long-term streamflow variability. It was also speculated that reduced intensity of seasonal ground freezing, together with precipitation increases, might drive increases in river discharge to the Arctic Ocean. However groundwater ages are not much known yet. In order to determine residence time of permafrost groundwater, hydrologic tracers such as tritium, chlorofluorocarbons (CFCs), and sulfur hexafluoride have been applied to the supra-permafrost and intra-permafrost groundwater in Yakutsk region of Eastern Siberia. The results showed that bulk groundwater age ranged from around 5 to 55 years old after the recharge. Because this bulk age is the mixture of those from supra-permafrost and intra-permafrost groundwater, it is necessary to separate the groundwater age from one to another. In this presentation, results of separated bulk age will be shown.

Keywords: permafrost, thermokarst, supra-permafrost groundwater, intra-permafrost groundwater, lake-talik-groundwater system

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MIS03-10 Room:101B Time:May 25 11:45-12:00

Land cover classification of West Siberian middle taiga and its application for estimating methane emission

Irina Kleptsova[1], Ilya Filippov[1], Elena Lapshina[1], Mikhail Glagolev[2], MAKSYUTOV, Shamil[3*]

[1]Yugorsky State University, Khanty-Mansyisk, Russia, [2]Moscow State University, Moscow, Russia, [3]National Institute for Environmental Studies, Tsukuba, Japan

Middle taiga zone occupies one fifth of the West Siberia plain and has the largest paludification area reaching about 35% of the territory. Raised oligotrophic bogs dominating there are the typical landscapes widely spread all over the northern hemisphere. As it was recently revealed, these bogs are not at present only the considerable sources of greenhouse gases into the atmosphere but also have a great potential in matter of global warming. In this study, the land cover classification for the middle taiga zone based on satellite images was conducted and used for the quantification of methane emissions from this area.

LandSat 5 and LandSat 7 images were used in the classification approach. Forests, wetlands and some other ecosystems were partly masked by normalized difference and green-red vegetation indexes. Mask and classified image noises were further rejected using original algorithms. A supervised classification of masked image was carried out using spectral bands 4, 5 and 3. Seventeen land cover classes of aquatic and terrestrial environments were assigned during the classification. Total methane emission was estimated basing on the data from 10 key sites including 681 methane emission measurements. Wetland classification of the whole area based on original Landsat data was achieved for the first time.

As it was considered earlier oligotrophic systems are dominating in West Siberian middle taiga. These wetland systems are firstly presented by forested raised bogs with dwarf pine-shrub-sphagnum communities (24.9% of the total wetland area) and by patterned bogs. The last ones are composed of ridge-hollow complexes (35.8%) combined with aquatic ecosystems (14.9%) and surrounding quacking mats (4.8%). Poor fens and fens are also found to be widely spread covering 17.2% of the total area. The rest of territory are occupied by drained and burned wetlands (2.2%).

Keywords: methane emission, wetlands, Landsat, mapping

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MIS03-11 Room:101B Time:May 25 12:00-12:15

Monitoring permafrost degradation in Siberia using microwave remote sensing sensor

SAKAI, Toru[1*], HIYAMA, Tetsuya[1], Junko Fujiwara[1], Semen Gotovtsev[1], Leonid Gagarin[2], Yasushi Yamaguchi[3]

[1]Research Institute for Humanity & Nature, [2]Melnikov Permafrost Institute, [3]Nagoya University

High latitude regions are experiencing the greatest climate warming. At Alazeya River Basin in the far north of Siberia, the annual mean air temperatures have risen by 4.6C for the last 50 years. The warming rate is 6.1 times faster than that of global average. The increase in air temperature thaws permafrost which underlays 25% of the northern hemisphere. Effects on permafrost thawing are particularly important for global climate, because permafrost thawing promotes decomposition of soil carbon, and releases greenhouse gases such as methane into the atmosphere. It is said that high latitude regions contain one third of the global terrestrial pool of soil carbon. Therefore, there is a concern that how permafrost thawing affects global carbon balance as positive feedback. In addition, permafrost thawing also changes water balance. As flood is caused when a large amount of the thawed water flows into the river, date of permafrost thawing is important. Extreme hydrologic events such as flood have already been observed, and are predicted to further increase in the frequency and magnitude. The objectives of this research are to monitor the process of permafrost thawing using remote sensing in the far north of Siberia, and to advance the knowledge about permafrost degradation to increased temperature. Annual mean air temperature at Alazeya is gradually increasing due to global warming, and air temperature in 2007 is extremely high. More permafrost melted during summer by warmer-than-normal air temperature. After ice wedge melting, water gushes from the ground. Then the water flows into a nearby river, leading to floods. Time-series of Landsat TM/ETM+ and ALOS/PALSAR detected flood damages. The flooded water flowed slowly toward the north, because landscape in this area is almost flat without slope. Therefore, the flood disaster in 2007 was carried over next year at Andryushkino. The local people suffer flood disasters for a long time.

Keywords: permafrost, Siberia, global warming, ALOS/PALSAR

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MIS03-12 Room:101B Time:May 25 13:45-14:00

Arctic warming, increasing snow cover and widespread boreal winter cooling

Judah L Cohen[1], Jason C Furtado[1], Mathew A Barlow[2], ALEXEEV, Vladimir[3*], Jessica E Cherry[3]

[1]Atmospheric and Environmental Research, Lexington, MA, USA, [2]University of Massachusets Lowell, Boston, MA, USA, [3]International Arctic Research Center, Fairbanks, AK, USA

The most up to date consensus from global climate models predicts warming in the Northern Hemisphere (NH) high latitudes to middle latitudes during boreal winter. However, recent trends in observed NH winter surface temperatures diverge from these projections. For the last two decades, large-scale cooling trends have existed instead across large stretches of eastern North America and northern Eurasia. We argue that this unforeseen trend is probably not due to internal variability alone. Instead, evidence suggests that summer and autumn warming trends are concurrent with increases in high-latitude moisture and an increase in Eurasian snow cover, which dynamically induces large-scale wintertime cooling. Understanding this counterintuitive response to radiative warming of the climate system has the potential for improving climate predictions at seasonal and longer timescales.

Keywords: global warming, climate dynamics, Siberian cooling

Japan Geoscience Union Meeting 2012
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MIS03-13 Room:101B Time:May 25 14:00-14:15

Study on the interannual variability and long-term trend of summer precipitation in East Siberia

YASUNARI, Tetsuzo[1*], Tatsuro Watanabe[2], Hatsuki Fujinami[1]

[1]Hydrospheric Atmospheric Research Center, Nagoya University, [2]Graduate School of Environmental Studies

In Eastern Siberia, there are great reaches of boreal forest, which play a great role in hydrological cycle and carbon cycle. Those boreal forest growths are closely related to interannual variability of summer precipitation. However, that in Eastern Siberia is poorly understood. In this study, I investigated dominant time-space patterns of interannual variability of summer precipitation in Eastern Siberia (90E-140E,50N-70N), using EOF (Empirical Orthogonal Function) analysis based upon daily precipitation grid data from 1979 to 2007. The association of the EOFs of monthly precipitation with atmospheric circulation water vapor transport (and its divergence) fields are additionally analyzed, using the global objective reanalysis data.

Analysis was made for the top three patterns of predominant patterns based on the contribution ratio of the EOFs. The first pattern (EOF1, contribution ratio: is 22.0%) represents the variation in the large area from central n to western region of Eastern Siberia (central Siberian highland) with that in opposite sign in southeast part of Eastern Siberia (far east Siberia). The second pattern (EOF2, contribution ratio: is 13.8%) represents a dipole-like pattern (in precipitation variability) between east and west part of Eastern Siberia. The third pattern (EOF3, contribution ratio: is 9.3%) represents pattern of summer precipitation variability in northeast in Eastern Siberia.

Those three variability patterns have been proved to occur as a result of interaction between the westerly waves along 60N with slight changes of trough (or ridge) system and water vapor field controlled by zonally-oriented water stationary vapor sources along 50-60N (possibly related to evapotranspiration from the boreal forest there) and by transport from the Arctic sea region.

In wet (dry) year in EOF1, deeper pressure trough (ridge) at around the Central Siberian Plateau (80E-120E) is likely to cause more (less) transport of water vapor from the Arctic sea (particularly from the Kara Sea). In wet (dry) year in EOF2, a pressure trough (ridge) at around western Central Siberian Plateau (80E) and a pressure ridge (trough) at around eastern Central Siberian Plateau (120E) is likely to cause more (less) water vapor transport from Laptev Sea (Arctic Sea) and less (more) transport from Kara Sea (Arctic sea). In wet (dry) year in EOF3, a pressure trough (ridge), remarkable only in a lower troposphere, extending from the Arctic Sea to Mongolia is likely to cause more (less) water vapor transport and convergence over regions of Verkhoyansk mountain Range and Mongolia.

Finally, geographical pattern (or classification) for interannual variations of precipitation has been deduced using the correlation analyses between the EOF patterns and gridded actual summer precipitation in Eastern Siberia: that is, the interannual variability of summer precipitation in western region of central Siberian plateau is relevant to EOF1 mode and that in Verkhoyansk Range on east bank of Lena River is relevant to EOF2 mode, and that in North Verkhoyansk Range is relevant to EOF3 mode. It has also been found that the summer precipitation amount in central Siberian plateau has shown increasing trend particularly since 1990s.

Keywords: precipitation, interannual variation and trend, East Siberia, water vapor transport, global warming, biosphere-atmosphere interaction

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MIS03-14 Room:101B Time:May 25 14:15-14:30

Seasonal and interannual variations of the Lena River discharge and their relationships to atmospheric water cycle

OSHIMA, Kazuhiro[1*], HIYAMA, Tetsuya[1]

[1]Research Institute for Humanity and Nature

River discharges from the three great Siberian rivers are a large source of freshwater inflows into the Arctic Ocean. The freshwater budget in the Arctic Ocean is important for local sea ice formation and for the ocean conveyor belt, which affects climate in Europe and several other regions. Sources of the freshwater inflow include river discharges from the land, net precipitation from the atmosphere, and ocean currents from the ocean. The river discharges from the three great Siberian rivers account for about 60% of the total river discharge into the Arctic Ocean and they also account for about 20% of the total freshwater inflow into the Arctic Ocean.

In principle, when calculated as an average over a long time period, the river discharge at the mouth of the river should be nearly equal to net precipitation integrated over the river basin area. The net precipitation is the difference between precipitation (P) and evapotranspiration (E), that is, the net input of water from the atmosphere to the land surface.

We used monthly mean river discharges observed near the mouths of the Lena, Yenisei and Ob Rivers from the ArcticRIMS archives, and 4 times daily specific humidity and winds from several atmospheric reanalyses. Because it is difficult to estimate net precipitation (P-E) from direct observations of P and E on large spatial scales, in our analysis, we estimated net precipitation on the basis of atmospheric reanalysis data without using P and E datasets. We calculated vertically integrated moisture flux using the atmospheric reanalysis and then estimated the net precipitation from the moisture flux and precipitable water by means of the atmospheric water budget method.

On average during 1980-2008, the amounts of net precipitation over the basins of the Lena, Ob and Yenisei Rivers were found to be comparable in magnitude to the river discharges at the mouths of each river. Our previous studies already produced good estimates of net precipitation over the Arctic and Antarctic regions (Oshima and Yamazaki 2004) and over the Amur River basin (Tachibana et al. 2008). Therefore, all these results indicate that the estimation of net precipitation by using atmospheric reanalysis is an effective way to evaluate and quantify the atmospheric and terrestrial water cycles of a large river basin or at larger spatial scales.

We further examined the seasonal and interannual variations of the river discharges and of the net precipitation for the Lena, Yenisei and Ob River basins, and in addition, how these variations are related with the atmospheric water cycle, that is, the moisture transport and associated large-scale atmospheric circulation. Some results are as follows. The Lena River discharge shows a maximum in June due to river ice melting. While the precipitation over the Lena River basin shows a maximum in July, the net precipitation shows a minimum at nearly zero flow in July. This indicates that the evapotranspiration is as large as the precipitation in the warm season. These seasonal cycles are almost the same as in the Yenisei and Ob Rivers. The net precipitation over the Lena River basin is mainly caused by transient moisture flux associated with cyclone activity; in contrast, over the Ob it is caused by stationary moisture flux associated with the mean flow, while over the Yenisei it is caused by both of stationary and transient fluxes. The summer and winter mean discharges of the Lena River are positively correlated with the net precipitations over the basin in each season, respectively. These variables do not show any significant trends during the past three decades (1980-2008).

Keywords: climate change, water cycle, Siberia, atmospheric reanalysis