

Progresses of MAIRS Dryland Study in East Asia

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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

Challenges for Managing Rangelands under Changing Climate in Arid Regions

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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, Adaption, Rangelands, Coupled Human-Environment

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

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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 decadal variabilities 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

Treeline dynamics under the climate changes in the Russian Altai Mountains

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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 Geocology 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

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

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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

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

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For a better understanding of the role of the terrestrial ecosystems in the global carbon cycle, atmospheric carbon dioxide (CO₂) and methane (CH₄) 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 CO₂ 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 CO₂ 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 CO₂ emission was exist even in cold season in Siberia. The CO₂ 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 CO₂ from 1993 to 2011 over Surgut was 1.9 ppm/year.

The seasonal variations of CH₄ 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 CH₄ in summer season was mainly resulted in CH₄ release from the wetland. Vertical differences in annual mean CH₄ between 7 and 0.5 km are 60 ppb over Novosibirsk and 85 ppb over Surgut, suggesting that large amount of CH₄ was released at ground surface especially from wetland near Surgut. Long-term trends of CH₄ observed over Siberia show rapid increase from 1997 to 1988 and stabilization after that. Siberian CH₄ started to increase again from 2007. At the altitude of 1 km, atmospheric CH₄ levels were highest over Surgut within 3 sites in Siberia, reflecting the strength of CH₄ emission around the observed area.

Keywords: CO₂, CH₄, aircraft, Siberia, carbon cycle, wetland

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

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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

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

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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

Age estimation of permafrost groundwater in Eastern Siberia

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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

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

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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

Monitoring permafrost degradation in Siberia using microwave remote sensing sensor

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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

Arctic warming, increasing snow cover and widespread boreal winter cooling

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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

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

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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

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

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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

Change in Terrestrial Ecosystem of Pan-Arctic and effect on Climate

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Terrestrial ecosystem of Pan-Arctic is an important part of Arctic climate system, which interacts with atmosphere and ocean and greatly affects global climate through a change in surface albedo, emission of green house gases, and so on. Those changes are expected to be caused by the interaction among vegetation, hydrology, and material cycling. Another important aspect of the Pan Arctic terrestrial ecosystem is distributions of permafrost and vegetation, which are very different condition spatially, therefore, a spatially different response to a warming environment is also expected.

Green Network of Excellence (GRENE) Arctic climate program by MEXT has initiated in 2011, and GRENE-TEA (GRENE Terrestrial Arctic Ecosystem) project has started in this program. Observation and research plans of GRENE-TEA project are introduced in our presentation.

Interdisciplinary observations, including permafrost hydrology, ecology, biogeochemistry, meteorology, climatology, dendrochronology, etc. are planned in Svalbard, Finland, eastern Siberia, Alaska, and Canada, to investigate the system. Systematic observation network is also established: long term observations at supersites, observation with mobile system to know a spatial variation near the supersites, and simple system for soil temperature measurements for numbers of sites are planned to obtain systematic dataset, which will promote joint research between observation and modeling works. Cooperation between observation and modeling works is one of the important challenges in the program.

Keywords: Arctic, ecosystem, permafrost, vegetation change, methane

Analysis of Siberian CH₄ flux during 1994-2010

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A vast Siberian forest area and the largest West Siberian wetland area in the world play a significant role in the global carbon cycle as a large carbon sink and a major natural source of atmospheric CH₄. Moreover the high Siberian Arctic land areas containing thick permafrost layers with carbon rich soils could release high CO₂ and CH₄ emissions thawing under a warmer climate. In this study, we estimate monthly CH₄ fluxes for 43 regions including 4 regions over Siberia during 1994-2010 using a fixed-lag Kalman smoother and investigate the year-to-year variation of Siberian CH₄ flux to understand climate-induced changes in Siberian CH₄ flux and the significance of Siberia on year-to-year variation of global CH₄ budget. Continuous and event measurement data of atmospheric CH₄ taken from WDCGG are inverted to optimize CH₄ fluxes in this study. Airborne observations of CH₄ at three sites over Siberia are used to adjust the magnitude of Siberian CH₄ flux with inverse modeling: at Surgut over wetlands and at Novosibirsk and Yakutsk over forests. We use interannually varying CH₄ emissions and interannually repeating OH, Cl and O₁D radicals provided by TransCom-CH₄ project (Patra et al., 2011) in forward simulation by NIES transport model (Belikov et al., 2011).

Keywords: Siberian CH₄, inverse modeling

Linkage between net ecosystem exchange of H₂O and CO₂ over boreal forest at eastern Siberia

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To improve our understanding of C/H₂O/energy exchange over eastern Siberia boreal forest, two observation sites at a larch dominated forest in the middle and southern part of Lena basin were compared. One is the Spasskaya Pad station at Yakutsk YK (62.25N, 129.23E). The other station named Elgeei EG (60.00N, 133.82E) is located at 300 km southeast of Yakutsk. Average of annual precipitation during 1986-2004 is 290mm and 230mm at Ust-Maya, which is the nearest station at a distance of 60km from Elgeei, and Yakutsk, respectively, while difference of the other meteorological values such as air temperature and humidity is small (Suzuki et al., 2007). The dominant species in the forest is larch (*Larix cajanderi*), mixed with birch (*Betula pendula*), willow (*Salix bebbiana*) and pine (*Pinus sylvestris*). The stand density of larch trees is 1040 trees ha⁻¹ (2600 trees ha⁻¹ including birch, salix and pine) and the mean stand height of upper canopy, which is comprised of larch trees, is around 25m.

The observation during growing season of 2010 and 2011 shows following results: 1) Meteorological condition were not different at the two sites. 2) Seasonal change of ground environment such as soil water and temperature was a little different between the two sites; melting of frozen soil started at beginning of May at both sites, but growing ratio of melting depth (active layer depth) was larger at YK than EG. The soil water content was larger at EG than YK through the season. 3) Evapotranspiration measured by the eddy covariance system showed similar way of seasonal change and total amount was not so different, while Net ecosystem CO₂ exchange was 1.5 times at EG compared to YK. 4) Seasonal variation of evaporative coefficient (actual evapotranspiration / potential evaporation), ecosystem water use efficiency (CO₂ uptake / evapotranspiration) and their correlation to the environmental variables were not always similar for the two sites.

Keywords: evapotranspiration, carbon cycle, boreal forest

Socio-economic and land productivity analysis in Central Asia: CACILM SLM IS Inception phase results

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Sustainable land and water management is essential in the five Central Asia States (CAS), Kazakhstan (KAZ), Uzbekistan (UZB), Turkmenistan (TKM), Kyrgyzstan (KYR), and Tajikistan. The rural economies of CAC suffered catastrophic falls over the 1990-2000 period as these countries went from a centralized command system to a free-market system. These changes dwarf any long-term changes due to land degradation or restoration trends. To evaluate these changes in dynamics, three baseline years were chosen: (1) end of Soviet period (1990); (2) end of readjustment period (2000); and (3) the most recent typical year (2007 or 2006). Primary statistical data on demography and land use, crop and livestock production at the administrative regions (oblast and their sub-divisions, or rayons) levels for KAZ (4 southern oblasts only), KYR, TKM and UZB were collected by National Support Implementation Units of SLM IS teams. Thereafter, within the Central Asian Countries Initiative for Land Management (CACILM) Program, the Inception Phase was implemented. The received data were processed and analyzed to reveal the dynamics of the following socio-economic characteristics: (a) Demographic indicators that include population change, annual population growth, population distribution by area of residence, vital statistics; (b) Agro-ecological potential and food resources that include area of arable lands and pastures, arable land per capita, total yield, crop yield, livestock production and increase and decrease of livestock; (c) Food security characteristics that include wheat and rice production per capita, actual production of wheat and needs per capita, livestock products production; and (d) Anthropogenic pressure on agro-ecological resources (population density per 1sq km of total area, population density per 1sq km of arable area, livestock density per 100 ha of pasture). According to our estimates, in **Kyrgyzstan** during 1991-2007, the arable land area was reduced in the range from 0.5% (Batken oblast) to 33.4% (Osh oblast). About 24.9% reduction of the pasture land was observed in the Osh oblast, while in the rest of the KYR rayons the pasture land was increased from 0.6% (Naryn oblast) to 12% (Chui oblast) and the cattle population density per 100 ha of pastures decreased in Talas and Chui oblasts. In **Uzbekistan**, during 1990-2007: a considerable reduction of pastures in Andijan, Fergana, Bukhara, Syrdarya, Namangan, Samarkand and Khorezm oblasts is observed. In Bukhara, Syr-Darya, and Samarkand oblasts the arable lands were considerably reduced (by 24.9%, 13%, and 11.1%, respectively). In other oblasts the reduction was less prominent. Only in two oblasts, Djizak and Kashka-Darya, increases in arable lands were registered by 6.5% and 1.2%, respectively. The analysis of dynamics of livestock and poultry population during 1990-2007 shows a significant increase of the cattle number (including cows), sheep and goats across all oblasts of the country. In **Turkmenistan**, during the 1991-2007 period, the cattle population has significantly increased nationwide (by 140% from 899 to 2,157.7 thousands). Comparing 2007 versus 1991 and the oblast level, the cattle population has increased in the range from 59.2% (Lebap velayat) to 289% (Dashoguz velayat). The sheep and goat population at the end of the analyzed period (at 2007) has increased by 226.4%. In **Kazakhstan** we present (as an example) the findings for the Kyzyl-Orda oblast (in Southern Kazakhstan). Here, during the 1991-2007 period, the crop land area has reduced by 3.1%. The changes were spatially inhomogeneous. For example, reduction of arable lands is observed in Aral (84.7%), Syr-Darya (16.4%), Kazalin (15.7%), and Karmakshi (12.3%) rayons, but it is increased in Zhalagash rayon by 25.8%. Detailed socio-demographic and land productivity analysis will be given in full paper. The studies in the framework of the CACILM project were supported by GEF Secretariat/Asian Development Bank.

Keywords: CACILM, land use, land degradation, food security, socio-economic analysis

Very heavy rains and prolonged no-rain periods in the Pacific Sector of the Northern Extratropics

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Using the Global Historical Climatology Daily Network data set (GHCN-Daily), we assessed changes in intense precipitation (above 12.7 mm) and prolonged no-rain periods across the Northern Extratropics. Intense precipitation was further partitioned into heavy, very heavy and extreme daily and multi-day rain events. In this presentation, we shall focus on the regions adjacent to the Pacific Ocean: Asian Russia, Japan, Alaska, British Columbia, the western contiguous US, and northern Mexico.

During the past sixty years, increases in very heavy and extreme rainfall were documented in the warm season over most of the Northern Extratropics. In several of them, while the mean seasonal precipitation was decreasing, the frequencies of very heavy and extreme rain events were increasing or have not been changed. Recent updates and infill of precipitation data available through GHCN-Daily allowed us to confirm our previous findings (Easterling et al. 2000) of this behavior for Asian Russia and Japan. Decreases in summer rainfall totals and frequency here are accompanied by increases in the frequency of very heavy daily rain events. Moreover, over most of Northern Asia (Siberia, northeastern China), various characteristics of summer dryness (fire indices, PDSI, no-rain intervals) indicate drier weather conditions in the past several decades.

We conclude that the atmospheric component of the hydrological cycle over the northern extratropical part of the Pacific Rim became more variable in the past decades.

Keywords: intense rainfall, prolonged no-rain periods, Northern Extratropics, Pacific Rim

Changes in pan and visible evaporation over Asian Russia

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Pan evaporation can be considered as an estimate of potential evaporation because it characterizes seasonal or annual result of thermal and water exchange between the water surface and the atmosphere. By this reason, pan evaporation can be used in estimates of evapotranspiration. Visible evaporation (the difference between pan evaporation and precipitation) is an important characteristic of the regional water cycle. In humid climates, it indirectly indicates the total energy losses due to evaporation over the region. A positive value of visible evaporation indicates a deficit in the regional water budget, and the water demand by the atmosphere exceeds precipitation (so-called "dry" conditions are perceived). When precipitation exceeds pan evaporation, visible evaporation is negative (which corresponds to "humid" conditions). The more negative the visible evaporation, the wetter the region, and the excess water remains for runoff and for replenishing the underground water reservoirs.

Pan evaporation observations in the USSR began in the middle of 1950s. At the peak of the network extent (in the middle of 1980s) more than 200 stations performing these observations operated in Asian Russia. From 1990s the number of stations was significantly reduced, and at present data up to 2008 are available only at 90 stations, (up to 1999, at 110 stations).

Precipitation changes for the study territory were analyzed on the base of data from the archive created in the Russian Research Institute for Hydrometeorological Information that contains data from about 800 stations at the Asian Russia territory for 1966-2008.

Using all available data, the territory of Asian Russia was zoned according to the specific features of the dynamics of the pan evaporation totals during the warm period (May-September). Visible evaporation changes are estimated for each of selected region from 1966 to 2008. Analysis of visible evaporation changes during the past 40 years shows significant changes practically over the entire Asian Russia and the changes are most evident in the regions with permafrost.

Keywords: Pan evaporation, Visible Evaporation, Northern Asia, Russia

Observed effects of integrated water vapor on long-term diurnal temperature range changes over China

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Diurnal temperature range (DTR) is one of important index used to describe the climate change and variability. The decline in DTR has been observed over most global land areas in recent decades due to a faster increasing in daily minimum temperature (T_{min}) than daily maximum temperature (T_{max}). The changes of the DTR in different region generally are determined by many different factors. In this study, we will quantitatively assesses the strong damping effects of column-integrated water vapor on the long-term DTR over China using more homogenized datasets of observed daily extreme 2-meter temperature and the daily precipitable water (PW) derived from the radiosonde dataset. The result shows that the DTR derived from daily homogenized extreme temperature shows downward trends decreasing by about 0.2-0.5°C decade⁻¹ over most of China during 1960-2010 and by more than 0.5°C/decade over northern China in winter. The long-term DTR change is also significantly correlated with the tropospheric column-integrated water vapor ($r^2=0.60$), with a $dPW/dDTR$ slope of $\sim -9.7\%$ K⁻¹, which is particularly higher in summer and autumn.

Keywords: Diurnal temperature range, Water vapor, Observed effects, China

Representing subgrid snow cover and snow depth variability in a global land model: of-line validation

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Seasonal snow cover is a key variable in the global climate system because of its large impact on surface temperature and surface energy and water budgets. In the present study, we incorporated a subgrid snow cover parameterization, SSNOWD (Liston, 2004), into a land surface model, MATSIRO (Takata et al., 2003). SSNOWD assumes that the subgrid snow water equivalent (SWE) distribution follows a lognormal distribution function, accounting for the physical processes that produce subgrid SWE variability. Two sets of 29-year offline simulations were performed: one with and one without SSNOWD. The simulations were forced with a global meteorological dataset (Kim et al., 2009) which combined the JRA25 atmospheric reanalysis data (Onogi et al., 2007) with 5 observed-precipitation datasets. The simulated monthly snow cover fractions were compared with satellite-based MODIS snow cover fraction data (Hall et al., 2006). For the Northern Hemisphere, daily snow-covered area was also validated using the IMS snow analysis (National Ice Center, 2008). Both of these comparisons show that the original MATSIRO underestimates the snow cover fraction, especially for the accumulation season and/or the regions with relatively small amounts of snowfall. In contrast, the inclusion of SSNOWD improved the spatial pattern of snow cover fraction. The SSNOWD simulation agrees well with the IMS snow analysis and led to an improved seasonal cycle of snow-covered area in the Northern Hemisphere. This is because SSNOWD formulates snow cover fraction differently for accumulation season and ablation season, and represents the hysteresis of snow cover fraction for different seasons. The effects of incorporating SSNOWD on surface energy fluxes and hydrological properties were also examined using 5 ensemble runs with different precipitation forcing.