# Fire-induced forest transformations in the Zabaikalye region, southern Siberia

*Elena Kukavskaya[1], Ludmila Buryak[2], Eugene Shvetsov[1], Olga Kalenskaya[2], Susan Conard[3], Kirsten Barrett[4], Sergey Zhila[1]

1.V.N. Sukachev Institute of Forest, Siberian Branch of the Russian Academy of Sciences, Krasnoyarsk, Russia, 2.Siberian State Technological University, Krasnoyarsk, Russia, 3.US Forest Service, Rocky Mountain Research Station, Missoula, Montana, USA, 4.University of Leicester, Leicester, UK

Wildfires are one of the main disturbances in Siberia impacting on structure, sustainability, and carbon budget of boreal forests as well as on people’ infrastructure and safety. The Zabaikalye region located in the south of Siberia is characterized by one of the highest fire activity in Russia. We have estimated fire disturbances in the Zabaikalye region with a use of Institute of Forest satellite fire dataset and official fire statistic data. Both datasets show trend in significant growth of fire activity in the region. The highest fire activity is observed in the central and southern parts of the Zabaikalye region. Repeatedly burned forest area accounted 20% (6.86 million ha) of the total forest area in the Zabaikalye region with many sites burned 3-6 times over the last 15 years. We have evaluated *in situ* fire impact on tree stands, regeneration, fuel loads, and carbon emissions on a number of sites in light-coniferous (Scots pine and larch) forests of the region. Tree mortality depended significantly on fire type and severity as well as forest conditions. Carbon emissions on repeatedly burned areas were no more than 15-40% of carbon released in the sites previously undisturbed. Regeneration amount depended on the site conditions and fire characteristics. While in the larch forests grown on mesic and wet soils fires result in the increase of tree seedlings, insufficient number of regeneration was registered in the Scots pine stands of the dry poor soils as well as in the repeatedly disturbed sites. Soil erosion was observed at many sites burned by high severity fires and in the repeatedly burned areas. The transformation of forests to steppe ecosystems occurs in many areas of the repeatedly disturbed sites of the Zabaikalye region. We combined field observations with remotely sensed data to develop methods for detecting disturbance level and tracking ecosystem recovery remotely. Climate warming along with antropogenic factors (e.g., agricultural burning, illegal logging, etc.) change drastically fire regimes in the Zabaikalye region. 2015 was characterized by one of the severest fire seasons in the region for the last several decades with more than 500 houses burned and 11 people died. There is an urgent need for planning complex forestry and fire management activities designed specifically for the region that take into account trends in climate conditions and local anthropogenic and natural features of the area. This research was supported by the Russian Foundation for Basic Research (grant # 15-04-06567), Grant of the President of the Russian Federation (# MK- 4646.2015.5), and NASA Land Cover and Land Use Change Program.

Keywords: light-coniferous forests, area burned, fire consequences, carbon emissions, regeneration, steppification

 

# Quantifying wildfires in Central Siberia: linking “top-down” and “bottom-up” observation strategies

*Alexey Panov[1], Anatoly Prokushkin[1], Alexander Bryukhanov[1], Mikhail Korets[1], Evgenii Ponomarev[1], Allison Myers-Pigg[2], Patrick Louchouarn[2,3], Marina Bryukhanova[1], Nikita Sidenko[1], Rainer Amon[2,3], Meinrat Andreae[4], Martin Heimann[5]

1.V.N. Sukachev Institute of Forest SB RAS, Krasnoyarsk, Russia, 2.Department of Oceanography, Texas A&M University, College Station, Texas, USA, 3.Department of Marine Sciences, Texas A&M University, Galveston,Texas, USA, 4.Max Planck Institute for Chemistry, Mainz, Germany, 5.Max Planck Institute for Biogeochemistry, Jena, Germany

Boreal wildfires are large sources of reactive trace gases and aerosols, and their emissions, accounting for up to 20% of global C emissions from biomass burning, are believed to significantly influence the chemical composition of the atmosphere and the global earth’s climate system. Although the problem of quantifying direct emissions from wildfires has received attention, their calculations still remain uncertain due to problems with emission factors (i), available carbon for combustion (ii), and imprecise estimates of burned areas (iii). Linking simultaneous instrumental observations of atmospheric composition in fire plumes, GIS-based estimates of active fire spots, burned areas and related parameters (fire disturbances of vegetation, fire intensity etc), and *in-situ* calculations of changes in ecosystem C pools prior and after fire is a powerful tool to fill this gap in our knowledge.
Since 2006 the Zotino Tall Tower Observatory (ZOTTO; www.zottoproject.org) a research platform for large-scale climatic observations is operational in Central Siberia (60°48’N, 89°21’E). The data of the high-frequency trace gas measurements at the tower are used in atmospheric inversion studies to infer the distribution of C sinks and sources over central part of Northern Eurasia. We present the results of our multidisciplinary research to reducing uncertainties in quantifiyng fire influence on atmospheric composition deduced from the large-scale fires that occured in 2012 in the tall tower footprint area.
Analysis of air composition in fire plumes was based on time series of $CO/CO_2/CH_4$ mixing ratios measured at 300 m a.g.l. at ZOTTO. Air transport from specific wildfires upwind of the measurement site was traced based on ensembles of 24-hrs backward trajectories from ARL NOAA HYSPLIT model, while active fires were detected from Terra/Aqua MODIS satellite data. Burned areas were estimated based on Landsat ETM 5,8 satellite images. Additionally, a Normalized Burn Ratio index (*dNBR*), further ranged by a complementary field based Composite Burn Index (*CBI*), and a fire radiative power (*FRP*) provided estimates of fire disturbances of vegetation, fire intensity and the amount of biomass combustion. Field investigations were performed on study plots established after fire in the dominant ecosystems of Central Siberia (lichen pine, moss pine, mixed forest, dark forest and peat bog) where estimations of woody C pools and their geographical distribution were determined using a laser-based field instrumentation system. Aforesaid investigations allowed us calculations of total carbon emissions from the specific wildfires. Furthermore, chemical analysis of samples of atmospheric particulate matter (PM) was performed in fire plumes during the same time for identifying biomarkers, or compounds indicative of a unique biological source, and thus served as a powerful tool to trace the origin and transformations of organic matter (OM). Inter alia levoglucosan (1,6-anhydro-b-D-glucopyranose) and its isomers (mannosan and galactosan) as dehydro-monosaccharide derivatives formed exclusively during incomplete combustion of fuels containing cellulose/hemicellulose and lignin phenols (vanillyl, syringyl and cinnamyl phenols) and their compositional changes were used to differentiate signals among tissue types (woody/nonwoody)

 

and vascular plant groups (angiosperm/gymnosperm). The Lignin Phenol Vegetation Index (LPVI) as a quantitative parameter representing the entire characteristics of the vegetation was used to be an additional tool to partition OM among end-member sources.

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Keywords: Climate, Wildfires, Siberia, Boreal forests, Carbon cycle, Tall tower

# Mapping West Siberian wetlands using Landsat imagery for methane emission inventory

*Shamil S Maksyutov[1], Irina E Terentieva[2], Mikhail V Glagolev[3]

1.National Institute of Environmental Studies, Tsukuba, Japan, 2.Tomsk State University, Tomsk, Russia, 3.Moscow State University, Moscow, Russia

High latitude wetlands are important for understanding climate change risks because of projected growth of methane emissions. Fine scale heterogeneity of wetland landscapes pose challenges for producing the greenhouse gas flux inventories based on point observations. To reduce flux uncertainties at the regional scale, we mapped wetlands in the taiga zone of West Siberia (WS) on a scene-by-scene basis using a supervised classification of Landsat imagery. The training dataset was based on high-resolution images and field data that were collected at 28 test areas distributed across the region. Classification scheme was oriented on methane inventory applications and included 7 wetland ecosystem types composing 9 wetland complexes in different proportions. Accuracy assessment based on 1082 validation polygons indicated an overall map accuracy of 79%. The total area of the wetlands and water bodies was estimated to be 52.4 Mha. Various bogs prevail in the region and occupy 84% of the wetland area, while fens cover only 16% of the wetland area. A new Landsat-based map of WS’s taiga wetlands can be used as a benchmark for validation of coarse-resolution global land cover products and wetland datasets in high latitudes.

Keywords: methane emissions, wetland mapping, Landsat

# Simulation of $CO_2$ and $CH_4$ in Siberia using coupled Eulerian-Lagrangian model

*Dmitry Belikov[1,2,3], Shamil Maksyutov[1], Alexander Ganshin[3,4], Ruslan Zhuravlev[3,4], Motoki Sasakawa[1]

1.Center for Global Environmental Research National Institute for Environmental Studies, 2.National Institute of Polar Research, Tokyo, Japan, 3.Tomsk State University, Tomsk, Russia, 4.Central Aerological Observatory, Dolgoprudny, Russia

Siberia is an extensive geographical region with large amounts of plant biomass and soil organic carbon, so this region has a substantial sources and sinks of $CO_2$ and $CH_4$. The magnitude and distribution of $CO_2$ and $CH_4$ fluxes are still uncertain, so accurate estimation of carbon fluxes and study of $CO_2$ and $CH_4$ seasonal cycles in the subarctic regions are essential.
In this work, we use forward simulation employing the Global Eulerian-Lagrangian Coupled Atmospheric (GELCA) model in order to estimate $CO_2$ and $CH_4$ seasonal cycles in the subarctic. GELCA consists of an Eulerian National Institute for Environmental Studies global Transport Model (NIES-TM) and a Lagrangian particle dispersion model (FLEXPART). This approach utilizes the accurate transport of the Lagrangian model to calculate the signal near to the receptors, and efficient calculation of background concentrations using the Eulerian global transport model.
We setup a long simulation period to obtain a better understanding of the role of emissions (using a set of $CO_2$ and $CH_4$ emissions scenarios), and transport model characteristics, such as the stratosphere/troposphere exchange and tracers concentration variations in the troposphere. We also analyzed modeled and observed long and short-term trend, seasonal cycle of $CO_2$ and $CH_4$.
Model results were compared with observations from the World Data Centre for Greenhouse Gases (WDCGG 2015) and the Siberian observations obtained by the Center for Global Environmental Research (CGER) of the National Institute for Environmental Studies (NIES) and the Russian Academy of Science (RAS), from six tower sites (JR-STATION).
The analyses have shown that CELGA is effective in capturing the seasonal variability of atmospheric tracer at observation sites strongly influenced by local emissions and global transport at the same time.

Keywords: atmospheric transport model, carbon cycle, carbon dioxide, methane

# How might climate change affect the distribution, structure and productivity of major Siberian forest types?

*Nadezhda Chebakova[1], Elena Parfenova[1], Mikhail Korets[1], Susan Conard[2]

1.Sukachev Institute of Forests, Siberian Branch, Russian Academy of Sciences, 2.US Forest Service

Previous regional studies in Siberia have demonstrated climate warming and associated changes in distribution of vegetation and forest types, starting at the end of the 20$^{th}$ century. In this study we used two regional bioclimatic envelope models to simulate potential changes in forest types distribution and developed new regression models to stimulate changes in stand height in tablelands and southern mountains of central Siberia under warming 21$^{st}$ century climate. Stand height models were based on forest inventory data (2850 plots). The forest type and stand height maps were superimposed to identify how heights would change in different forest types in future climates. Climate projections from the general circulation model Hadley HadCM3 for emission scenarios B1 and A2 for 2080s were paired with the regional bioclimatic models. Under the harsh A2 scenario, simulated changes included: a 80-90% decrease in forest-tundra and tundra, a 30% decrease in forest area, a 5-fold increase in forest-steppe, and a 10-fold increase in steppe, forest-steppe and steppe would cover 55% of central Siberia. Under sufficiently moist conditions, the southern and middle taiga were simulated to benefit from 21$^{st}$ century climate warming. Habitats suitable for highly-productive forests (≥30-40 m stand height) were simulated to increase at the expense of less productive forests (10-20 m). In response to the more extreme A2 climate the area of these highly-productive forests would increase 10-25%. Stand height increases of 10 m were simulated over 35-50% of the current forest area in central Siberia. In the extremely warm A2 climate scenario, the tall trees (25-30 m) would occur over 8-12% of area in all forest types except forest-tundra by the end of the century. In forest-steppe, trees of 30-40 m may cover some 15% of the area under sufficient moisture.

Keywords: forest structure and productivity, bioclimatic models, climate change, 21st century, Central Siberia

# Satellite assessment of post-fire forest regeneration in the Zabaikal region

*Evgeny Shvetsov[1], Elena Kukavskaya[1], Ludmila Buryak[2]

1.V.N. Sukachev Institute of Forest SB RAS, 2.Siberian State Technological University

Fires are one of the most significant impacts on forests in Russia. Each year an area of several million hectares is exposed to the forest fires, with a significant increase in the burned area in certain years. In several regions of Russia, especially in the forests of southern Siberia an increase in fire frequency and the duration of the fire season is observed. The forests of Zabaikal region are among the most fire disturbed areas in Russia.
In this study we used MODIS 500-m surface reflectance products (MCD43A4) and 1-km active fire product (MOD14A1) over 2000 –2015 to monitor fire disturbed areas in south-west part of Zabaikal region. Joint analysis of vegetation indices (shortwave vegetation index –SWVI) derived from MODIS data and materials of in-situ research allowed us to distinguish areas with successful and poor forest regeneration on fire disturbed territories. The linear trend of the SWVI after the fire event was used to assess the state of forest regeneration. The area with poor regeneration was estimated to be more than 900 thousand hectares. Large areas of the Zabaikal region considered in this were exposed to repeated fires. An analysis of vegetation indices dynamics showed that areas affected by fires 2 times or more during the study period often experienced forest regeneration failure.
This study was supported by the Russian Foundation for Basic Research grant 15-04-06567.

Keywords: Forest fires, Vegetation indices, Forest regeneration

# Gaps and Pathway of Integration between Natural and Social Sciences in Global Change Research

*Likun Ai[1]

1.Institute of Atmospheric Physics, Chinese Academy of Sciences

The transdisciplinary study between natural and social sciences is very challengeable because of their differences in research subjects, objectives, data and methodology. In recent 20 years, the merging sustainability sciences in climate, environment, ecosystem, energy, food, resources and human health provide the new opportunity for integration between natural and social sciences. This talk is focusing some methodologies on how to integrate these two types of sciences in sustainability science. First, the integrated study between natural and social sciences should be solution-oriented, and co-design, co-production with other stakeholders. Secondly, the integrated study should be balanced in top-down (natural) and bottom-up (social) approaches, focusing on the scientific issues in local level, which needs the efforts on social upscaling and natural downscaling by overcoming the uncertainties. To communicate the knowledge of uncertainties is one of the most important tasks for natural scientists when they try to work with social scientists and stakeholders. Last, we bring out some discussion on needs of experts in charge of communication in transdisciplinary study, the tendency of looking down social science in current global change and sustainability research, and the mismatching of current evaluating system to sustainability science.

Keywords: global change, natural and social sciences, vulnerability and adaptation , transdisciplinary

# Agricultural and Pastoral Systems as Nexus of Food and Water in Dryland Asia

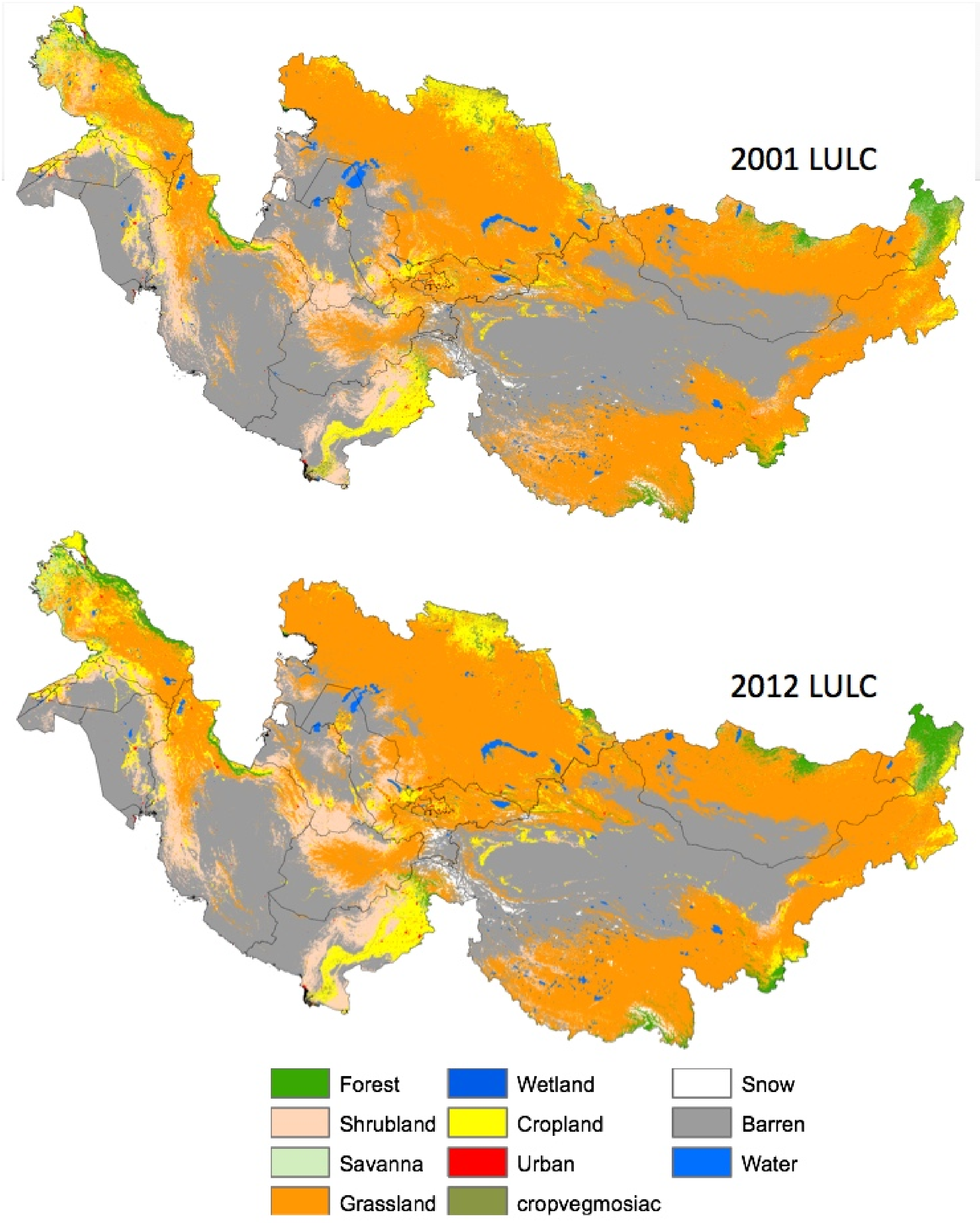
*Jiaguo Qi[1,2], Xiaoping Xin[4], Dennis Ojima[5], Pavel Groisman[3], Jiquan Chen[1]

1.Center for Global Change & Earth Observations, Michigan State University, 2.Zhejiang University, 3.University Corp. for Atmospheric Research at the NOAA National Centers for Environmental Information, Asheville, NC, USA, 4.Chinese Academy of Agricultural Sciences, Beijing, China , 5.Colorado State University, Ft. Collins, CO, USA

It is estimated that by 2050 the global demand for food will be increased by 60%, water by 55% and energy by 80% (OECD-FAO, 2012; IRENA, 2015) in order to meet the needs of current and additional new 2.2 billion of people on the planet. The demand for additional food lies not only in producing the basic resources needed to sustain a healthy lifestyle, but also from a changing diet, especially in rapidly developing countries around the world. It is projected that the growing demand for meat will require additional 0.2 billion tons per year by 2050, which almost doubles the present meat consumption. These new demands create mounting pressures on agriculture and pastoral ecosystems. Furthermore, the anticipated trajectory of future warmer and drier climates major agricultural regions of the world increases uncertainties in food security, adding further stresses to the already stressed nations particularly those in the Asian dryland belt.
Given the complexity and interplay among the food, water and energy in dryland ecosystems, the questions arise 1) whether or not the existing agricultural and pastoral ecosystems are endowed to have the capability to produce the required food, given its nexus to water and energy, 2) whether or not the current land use and consumption practices are sustainable when considering other ecosystem services critical for societal sustainable development, and 3) what are alternatives to ensure a sustainable trajectory of regional development to meet the new food demand?
This presentation reviews existing practices and proposes alternative solutions from both producer and consumer perspectives. The focus will be specifically on examining the trade-offs between different ecosystem services that drylands in Asian may provide. Preliminary analysis suggested that the current trajectory of meat and milk production is likely not on a sustainable pathway.

Keywords: Drylands Asia, Food and Water Nexus, Food Security, Ecosystem Services


2001 LULC
2012 LULC
Forest
Wetland
Snow
Shrubland
Cropland
Barren
Savanna
Urban
Water
Grassland
cropvegmosiac

# Current state and dynamics of glaciers in the Mountains of Northwest Inner Asia

*Margarita Syromyatina[1], Yurii Kurochkin[1], Mariia Mukhanova[1]

1.Institute of Earth Sciences, Saint Petersburg State University, Russia

The mountains of Northwest Inner Asia have traditionally been a subject of special interest to geographers of St.Petersburg State University. The region is characterized by arid climate, existence of modern glaciation centers and sparse growth of forest cover. One of the key sites is Tavan Bogd Mountains with the largest valley glaciers of the entire Altai region. This mountain massif is located at the junction of the Russian and Mongolian Altai ranges on the border of Russia, Mongolia and China. The glaciers of Tavan Bogd are concerned with formation of the main river in western Mongolia - Khovd river related to the endorheic basin of Grate Lakes Depression. Khovd river plays a critical part in the water supply of submontane desert steppe plains of this region. Current state and dynamics over the past decades of the Tavan Bogd glaciers are investigated on the basis of results obtained in 2013-2015 field glaciological, meteorological and dendrochronological observations as well as remote sensing data acquired from satellites.
Ground-based geodetic survey and aerial survey from unmanned aircraft system (UAS) allowed generating high-resolution orthomosaics and DEMs of the glaciers.
This study examined 39 glaciers with a debris-free glacier area of 68 sq.km in the Tsagaan-Gol River basin and 41 glaciers with an area of 31 sq.km in the Tsagaan-Us River basin. The areas of the main glaciers were not much changed since 1989, while the glacier tongue regression was fixed. The total glacier area decreased approximately by 4.5 % (3.2 sq.km) in the Tsagaan-Gol basin and by 6.9 % (2.3 sq.km) in the Tsagaan-Us basin from 1989 to 2013. Kozlov Glacier was retreating at an average rate of 34 m/year between 2001 and 2014. Potanin Glacier was retreating slowly between 1989 and 2001 at an average rate of 5-10 m/year and more active between 2001 and 2014 at an average rate of 28 m/year. On the base of the 2005-2014 weather station data, ablation observations and equilibrium line monitoring the glaciological and climatological characteristics such as temperature lapse rate, ablation-accumulation and precipitation values at equilibrium line altitude were calculated. Ablation-accumulation value amounts to 110 g/sq.cm at mean summer temperature on the equilibrium line of 1°C. These calculations give us an opportunity to pass on to glacioclimatic modelling and mass balance estimations.
Instrumental measurements in this region in general overtake no more than last 50 years. Using the dendrochronological data from 479 living trees of *Larix sibirica* collected on the 38 sites in the Tuva Mountains and Mongolian Altai two regional chronologies were obtained. They reflect growth conditions on the upper (UTL) and lower (LTL) tree lines. Strong statistical signal (R=0.73) allowed receiving reconstruction of June-July air temperature since 1715 year. LTL chronology has strong connection with hydrological records (R=0.65). A May-June streamflow of Buyant river since 1474 year was reconstructed. We detected trends and cyclicity (11-year solar cycle, 30-35 year Bruckner cycle and others) in tree-ring growth and reconstructions.

Keywords: glacier fluctuations, glacioclimatic modelling, dendrochronological reconstructions, Altai region, Tavan Bogd Mountains

# Extreme Heat events during 1971-2011 in Xi’an, China

*YuXia Ma[1], Bingshuang Xiao[1], Chang Liu[1], Yuxin Zhao[1], Xiaodong Zheng[1]

1.LZU Lanzhou University

Exposure to extreme heat is already a significant public health problem nowadays. In this study, the daily data of the maximum temperature and mean temperature in Xi 'an from 1971 to 2011 were used to statistically analyze the monthly, inter-annual and inter-decadal change of heat events and the high temperature days in Xi 'an, and the global mean NCEP reanalysis data were used for explaining the cause of the most and least heat events and high temperature days in 1997 and 1983 respectively. Urban heat island effect was also analyzed using the difference of temperature between Xi’an and the suburbs. The causes of the abnormal high temperature were explained using synoptic weather maps of 500hPa and 700hPa. WMO defined heat wave as the daily maximum temperature is above 32$^0$C and lasts more than 3 days. In this paper, heat wave was defined as the daily maximum temperature was above 35$^0$C and lasted more than 3 days according to the “stove” climate of Xi’an. If the daily maximum temperature is above 38$^0$C and 40$^0$C, it is called severer high temperature and the severest high temperature (or intense heat) day respectively. It revealed that: (1) high temperature in Xi’an appeared frequently in June, July and August. The annual number of high temperature days and heat wave peaked in 1997 and reached a minimum in 1983 in Xi’an. The numbers of high temperature days were 60 and 1 respectively. The heat waves were 9 and zero respectively. The numbers of high temperature days and heat waves were consistent, (2) the average temperature and maximum temperature increased obviously from the 1980’s and increased more outstanding in urban areas than in the suburbs. The linear increase trend of average temperature were 0.621 $^0$C /10a in downtown, much higher than 0.216 $^0$C /10a and 0.350 $^0$C /10a in the suburb of Chang’an district and Gaoling respectively. The average numbers of high temperature days were 27.3, 26.9 and 28.7 in downtown, suburb and outer suburb respectively. And the frequencies of heat wave were 3.9, 3.6 and 3.9 in downtown, suburb and outer suburb respectively. (3) the differences of average temperature between urban and the suburbs (suburb and outer suburb) increased obviously. The linear trends of differences were 0.385 $^0$C /10a and 0.231 $^0$C /10a in suburb and outer suburb respectively. Urban heat island effect was a big factor of heat events in Xi’an, (4) circulation analysis showed the cause of the least heat waves in 1983 and the most in 1997. In July 1997, the Tibetan high and Western Pacific subtropical high were very strong and connected each other in northern Xi’an on 500hPa. And south-west and south-east airflow controlled Xi’an during the heat waves, resulting humid and hot weather. In July 1983, the Western Pacific high was weaker and located in lower latitude. Therefore, southern airflow to Xi'an was weak, resulting the least high temperature days in 1983.

Keywords: Heat events, Urban heat island , atmospheric circulation analysis

# Climate Change and Urban Infrastructure: Quantitative Assessment for Russian Permafrost Regions

*Nikolay I Shiklomanov[1], Dmitry A. Streletkiy[1]

1.The George Washington University

Planned socio-economic development during the Soviet period promoted migration into the Arctic and work force consolidation in urbanized settlements to support mineral resources extraction and transportation industries. One of the most significant impacts of climate change on arctic urban landscapes is the warming and degradation of permafrost which negatively affects the structural integrity of infrastructure. In this paper we focus on quantitative assessment of potential changes in stability of Russian urban infrastructure built on permafrost in response to projected climatic changes using permafrost - engineering model. To address the uncertainties in climate projections produced by state-of-the art General Circulation Models (GCMs), we have utilized results from six GCMs participated in most recent Climate Model Inter-comparison Project (CMIP5). The analysis was conducted for entire extent of the Russian permafrost-affected area and on several representative urban communities. Our analysis demonstrates that significant climate-induced reduction in urban infrastructure stability throughout the Russian permafrost region should be expected by mid XXI century. Although high uncertainty, resulted from GCM-produced climate projections, prohibits definitive conclusion about the rate and magnitude of potential climate impacts on permafrost infrastructure, the results presented in this paper can serve as guidelines for developing adequate adaptation and mitigation strategy for Russian northern cities.

Keywords: Urban infrustructure, Permafrost, Climate change, Russia

# Freezing Precipitation and Freezing Events over Northern Eurasia and North America

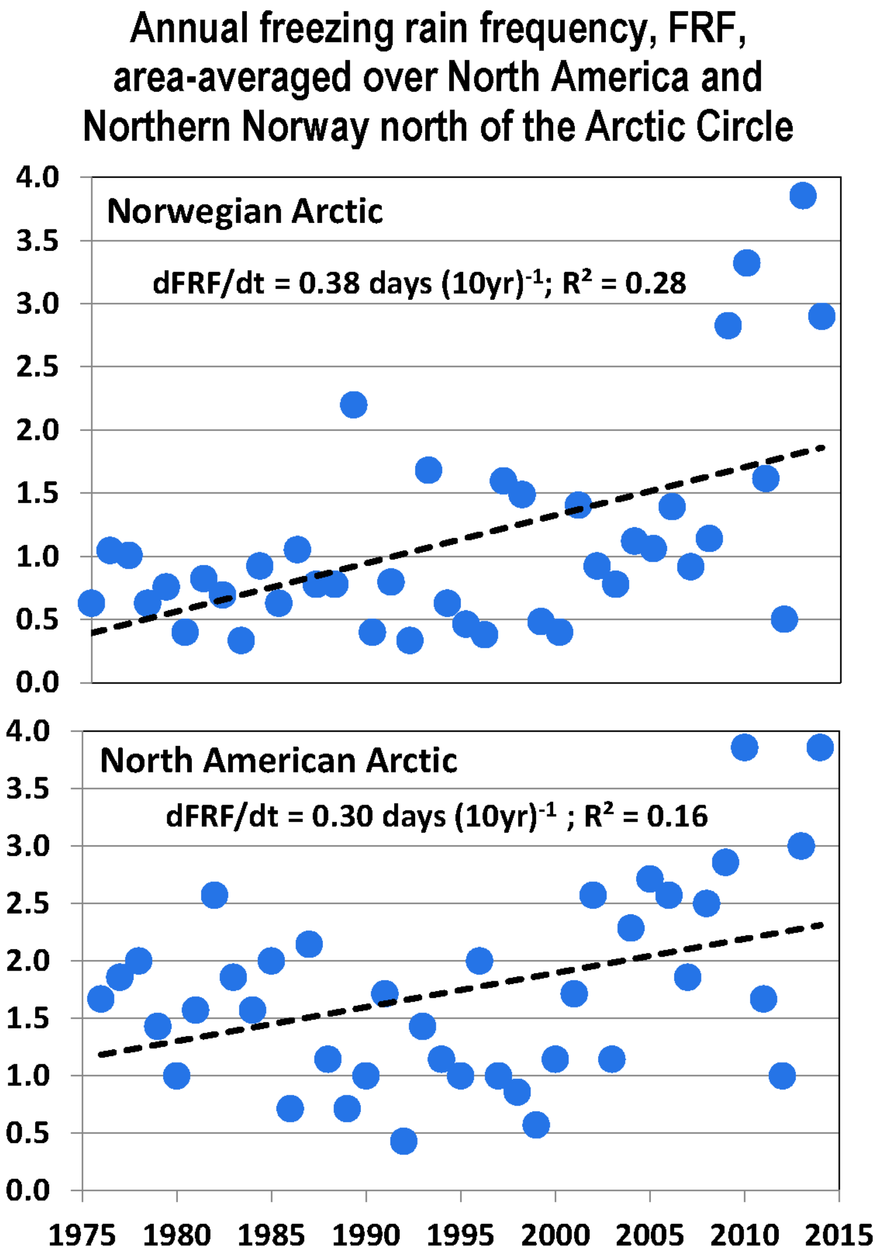
*Pavel Groisman[1,4], Xungang Yin[2], Olga Bulygina[3,4], Irina Partasenok[5,4], Olga Zolina [6,4], Inger Hanssen-Bauer[7]

1.University Corp. for Atmospheric Research Project Scientist at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA, 2. ERT, Inc. at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA, 3. All-Russian Research Institute of Hydrometeorological Information—World Data Centre, Obninsk, The Russian Federation, Obninsk, Russia , 4. RAS P.P. Shirshov Institute for Oceanology, Moscow, The Russian Federation, 5. Republican Hydrometeorological Centre, Minsk, Belarus, 6. Le Laboratoire de glaciologie et géophysique de l'environnement, Grenoble, France, 7. Norwegian Meteorological Institute, Oslo, Norway

With global climate change in the extratropics, the 0°C isotherm will not disappear and associated precipitation events will continue to occur. The near-0°C temperatures should generally move poleward and to the higher elevations and arrive at many locations earlier in spring or later in autumn. This could potentially affect the seasonal cycle of near-0°C precipitation. The overall warming, together with a larger influx of the water vapor in the winter atmosphere from the oceans (including ice-free portions of the Arctic Ocean) can also affect the amount of near-0°C precipitation. The issue of near 0°C precipitation is linked with several hazardous phenomena including heavy snowfall/rainfall transition around °C; strong blizzards; rain-on-snow events causing floods; freezing rain and freezing drizzle; and ice load on infrastructure.
In our presentation using more than 1,500 long-term time series of synoptic observations for the past four decades, we present climatology and the empirical evidence about changes in occurrence, timing, and intensity of freezing rains and freezing drizzles over five countries of Northern Eurasia and two countries of North America.
The regions with the highest frequency of freezing rains (from 3 to 10 days per year) reside in the northeastern quadrant of the conterminous United States and adjacent areas of southeastern Canada south of 50°N, over the south and southwest parts of the Great East European Plain, and Central Europe. The frequency of freezing drizzle exceeds the frequency of freezing rain occurrence in all areas. During the past decade, the frequency of freezing rain events somewhat decreased over the southeastern U.S. In North America north of the Polar Circle, it increased by about 1 day $yr^{-1}$.
Over Norway, freezing rain occurrences increased substantially, especially in the Norwegian Arctic. In European Russia and western Siberia, the frequency of freezing rain generally increased (except the southernmost steppe regions) while freezing drizzle frequency decreased over entire Russia. The number of days with freezing events over Belarus did not change, however, the duration of these events (in hours) substantially increased. In the mountains of Central Asia (Kyrgyzstan) we documented increases in freezing rain and drizzle frequencies only at high elevations, while they decrease at elevations below 1 km (matching to a similar decrease over the steppe zone of southern Russia).
In the former Soviet Union, instrumental monitoring of ice load has been performed by ice accretion indicator that in addition to the type, intensity and duration of ice deposits reports also their weight and size. Estimates of climatology and changes in ice load based on this monitoring at 958 Russian stations will be also presented.
This work is supported by the Ministry of Education and Science of the Russian Federation (grant 14.B25.31.0026) and the NASA LCLUC Program.

Keywords: freezing precipitation, climatic change, northern extratropics



# Fire impact on forest formation in the light-coniferous forests of the southern Siberia

*Ludmila Buryak[1], Olga Kalenskaya[1], Elena Kukavskaya[2]

1.Siberian State Technological University, Krasnoyarsk, Russia, 2.V.N. Sukachev Institute of Forest, SB RAS, Krasnoyarsk, Russia

Wildfire is the main disturbance factor in the boreal forests of Siberia. The majority of fires occur in the south of Siberia where the highest anthropogenic pressure is observed. We have examined in situ fire effects at 570 sample plots for the last 15 years. Forest formation process in the light-coniferous forests of the southern Siberia was found to depend significantly on zonal and geographic particularities of the forest lands. Different forest regions are characterized by specific factors of forest formation, which impact on fire behavior and its consequences. Fire tolerance of the tree species and stands depends on the ecological demands of the trees, terrain, and forest conditions. Postfire tree mortality depends greatly on the fire characteristics and periodicity. The biggest stand damage after surface fires in the southern Siberia was found in the forests of Angara region and Altai-Sayan mountain region. Tree mortality in the similar forest conditions after fires of identical type and severity could differ 2-4 times depending on the region. High-severity steady fires in all forest regions of Siberia result in nearly all or total tree mortality. Anthropogenic factors often increase negative fire consequences. Climate warming causes droughts intensification and change of fire regimes thus leading to the steppification and desertification of the forested lands and extension of the rocky areas. These processes mainly happen in the southern latitudinal forest border (forest-steppe zone in the southern Siberia and southern regions of the Zabaikalsky krai), as well as in the lowest and highest altitudes (more often –in the southern slopes). Wildfires accelerate transformation of the forests and shift of the borders zones and subzones. Based on our field data, with a use of satellite images and forest inventory datasets, we were able to develop methodology to forecast postfire forest ecosystem state and estimate natural fire danger dynamics. This research was supported by the Russian Foundation for Basic Research (grant # 15-04-06567) and NASA Land Cover and Land Use Change Program.

Keywords: fire type and severity, tree mortality, zonal and geographic particularities

# Soil $CO_2$ efflux rates after wildfires in ecosystems of Central Siberia

*Alexey Panov[1], Galina Zrazhevskaya[1], Mikhail Korets[1], Alexander Bryukhanov[1], Nikita Sidenko[1], Anastasya Timokhina[1], Martin Heimann[2]

1.V.N. Sukachev Institute of Forest SB RAS, Krasnoyarsk, Russia, 2.Max Planck Institute for Biogeochemistry, Jena, Germany

Fire is a main disturbance factor in boreal forest ecosystems, which is very important to the ecology of these sensitive forests and plays a central role in carbon cycling. The rapid influence of fire on carbon cycle occurs through the emission of carbon into the atmosphere during biomass burning. Besides this direct influence fire initiates succession and thus regulates patterns of C accumulation through net primary production and also influences the soil thermal and moisture regime, which, in turn, affect patterns of soil respiration.
Since 2006 the Zotino Tall Tower Observatory (ZOTTO; www.zottoproject.org) a research platform for large-scale climatic observations is operational in Central Siberia (60°48’N, 89°21’E). The data of high-frequency trace gas measurements at the tall tower are used in atmospheric inversion studies to infer the distribution of C sinks and sources over central part of Northern Eurasia. We present our estimates of carbon release through soil respiration in boreal forest ecosystems of Central Siberia after large-scale fires that occured in 2012 in the tall tower footprint area.
Burned landscapes in the tall tower footprint area were estimated based on Landsat ETM 5,8 satellite images. For selected burned areas a magnitude of ecological change caused by fires (“burn severity”) was measured and mapped with a Normalized Burn Ratio index (*dNBR*) and further calibrated by a complementary field based Composite Burn Index (*CBI*). Additionally, values of combustion efficiency (*CE*) for studied areas were calculated based on the time series of $CO/CO_2$ mixing ratios measured at 300 m a.g.l. in fire plumes while air transport from specific wildfires upwind of the measurement site was traced based on ensembles of 24-hrs backward trajectories from ARL NOAA HYSPLIT model. Active fire spots were detected from Terra/Aqua MODIS satellite data. Field investigations were performed on study plots established after fire in the dominant ecosystems of Central Siberia (lichen pine, moss pine, mixed forest, dark forest and peat bog) where estimations of woody C pools and their mapping were made with a laser-based field instrumentation system. Soil respiration rates were measured within the plots using a dynamic closed chamber method by a portable LI-6400 system.
Within all studied ecosystems soil efflux rates 3 yrs after fire demonstrated 15 - 25% lower values compared to pre-fire conditions. The highest values within ecosystems after fire have been found out in wet and less disturbed dark and mixed forests (up to 3,8). In these ecosystems fires occured mostly in a smoldering phase (*CE* = 0,92 - 0,93) and a field calibrated *dNBR* didn’t exceed 25 –30%. Such fires could cause only a surface mineralization that resulted in soil fertilization after fire and a spread vegetation cover was found within the plots. A linear regression analysis has shown a good correlation ($r^2$=0.91 –0.98) of soil efflux rates and soil temperature (10 cm depth), which confirms the essential input of autotrophic respiration into a total C flux. In turn the lowest values (≈ 2,5) were typical within the dry pine stands with the highest *dNBR* (≈ 45%), where *CE* could reach up to 0,99 demonstrating a prevailing flame phase of fire. Within these plots we found out >80% of dead trees and highly damaged vegetation cover with patches of exposed mineral soil. Decomposition processes in C cycling of such ecosystems are believed to be prevailing. Linear regressions analysis of efflux rates and soil temperature didn’t demonstrate any correlation ($r^2$ =0.02), which also suggests a primarily heterotrophic origin of C flux.
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Keywords: Wildfire, Siberia, Carbon balance, Soil respiration

# Assessing pyrogenic impact on Scots pine (*Pinus sylvestris L.*) stands after surface fires in Central Siberia

*Alexander Bryukhanov[1], Alexey Panov[1], Nikita Sidenko[1]

1.V.N. Sukachev Institute of Forest SB RAS

In the face of increasing number of wildfires, there is no doubt about large uncertainties existing in their assessing which occur mostly on the stage of ground investigations. Whereas a lot of remote sensing data on fires are developed intensively, accurate *in situ* estimates of fire induced changes in ecosystems are still the most variable and sparse. A laser-based field instrumentation system supplemented by the other measurements (assessment of woody carbon pools, forest evaluation, vegetation and soil descriptions etc.) provides a powerful tool for comprehensive description of spatial development of wildfires within the study area. Such observations demonstrate the spatial heterogeneity of burns and how fire interacts with vegetation and topography. It permits analysis of relationships between spatial parameters and intensity of burning and thus providing estimations of fire damage of trees linked with many other related parameters within the area (such as undergrowth, slash, etc.).
Field investigations were performed on study plots established in the dominant ecosystems of Central Siberia (lichen pine, moss pine, mixed forest, dark forest and peat bog) after large-scale fires that occurred in 2012. Using a linear regressions analysis we have selected two main factors that are vital for Scots pine in survival during high-intensity ground fire: individual characteristics of a tree and spatial location (type of damages, stores of biomass available for combustion around the tree) ($R = 0.81$) and the diameter of root collars ($R = 0.86$). Surface location of root system has been found to be a reason of a strong drop in fire-resistance of Scots pine. Within the fast-moving surface fires we found out that dead trees with surface location of root system reached around 42% and after steady surface forest fire mortality could achieve up to 91%. Individual morphometric parameters of trees (big-butt, slope, and curvature of a stem) have been found to be a next influential factor of tree mortality. We found out that visible post-fire damages of stem were deadly significant for Scots pine mature trees if fire scars reached more than 2/3 of circumference (for damage of cambium layer). Such damages could be a reason of 89% mortality of Scots pine trees. In such cases if tree survived after the fire, it could be destroyed by the next fire due to increased pitch flow, which decreases fire-resistance of the tree. These results confirm that for mature pine stands surface forest fires are as dangerous as crown fires.
This research was supported financially by the project of RSF # 14-24-00113 and RFBR grant # 15-45-04423.

Keywords: Central Siberia, Scots pine, surface forest fires, root collar, impact of wildfire, estimations of fire damage

# Climatic fluctuations of the terrestrial atmosphere in Central Siberia: long-term monitoring at ZOTTO observatory

*Nikita Sidenko[1], Alexey Panov[1], Olaf Kolle[2], Martin Heimann[2]

1.V.N. Sukachev Institute of Forest SB RAS, Krasnoyarsk, Russia, 2.Max Planck Institute for Biogeochemistry, Jena, Germany

In this study we present the analysis of climatic data for the prevailing ecosystem types in the footprint area of the Zotino Tall Tower Observatory (ZOTTO; www.zottoproject.org), a research platform for large-scale climatic observations that is operational in Central Siberia (60°48'N, 89°21'E) since 2006. The data of the high-frequency trace gas measurements at the tall tower are used in atmospheric inversion studies to infer the distribution of carbon sinks and sources over central part of Northern Eurasia. Thus knowledge of climatic fluctuations of the terrestrial atmosphere linked with time series of trace gases and aerosols measured at the tall tower are vital for our understanding how they are affect each other.
Systems to measure environmental variables were installed at the tall tower and local ecosystems (pine forest, peat bog). Climatic data for the period 2009 - 2015 yrs used in this study were collected during continuous high-frequency WMO sertified measurements of the main meteorological parameters: air temperature and air humidity (Combined temperature and humidity probe KPK1-6-ME-H38, MELA Sensortechnik GmbH, Germany), precipitation (Precipitation transmitter 5.4032.35.009, Adolf Thies GmbH, Germany), air pressure (Air pressure sensor 61202V/61302V, R.M.Young, USA), wind speed and direction (Ultrasonic-anemometer 3D 1210-R3 / R3-50, Gill Instruments Ltd. UK; 3D heated METEK USA-1, METEK GmbH, Germany), solar radiation (Combined net radiometer CNR1, Kipp & Zonen B.V., Netherlands), soil temperature (Soil temperature sensor 902830-Jumo, Jumo GmbH, Germany) and soil moisture (Soil moisture probe ML-2x, Delta-T Devices, UK). In this study method of climatic and microclimatic observations was used.
Results reflect atmospheric conditions and processes, and demonstrate direct and inverse feedbacks between mesoclimatic conditions in study area and the processes in global earth's climate system. We found out that western wind drift is a prevailing for study area and continental polar air could be a reason of a strong radiation cooling effect in wintertime. Climatic parameters reflect the typical continental conditions of the region. Wind rose demonstrated mainly southeast wind directions that can be attributed to impact of the Asian anticyclone. However during the period of measurements the cyclonic activity in the region was unstable and could contribute to the climate conditions both on regional and continental levels. Due to the relatively high homogeneity of the landscape in study area the derrived results are representative for the tall tower footprint area (1000 $km^2$) and can catch even larger territory of Central Siberia.
This research was supported financially by the Max Planck Society (Germany), project of RSF # 14-24-00113 and RFBR grant # 15-45-04423.

Keywords: Climate, Siberia, Greenhouse gases, ZOTTO

# Northern Eurasia Future Initiative: Facing the Challenges of Global Change in the 21st century

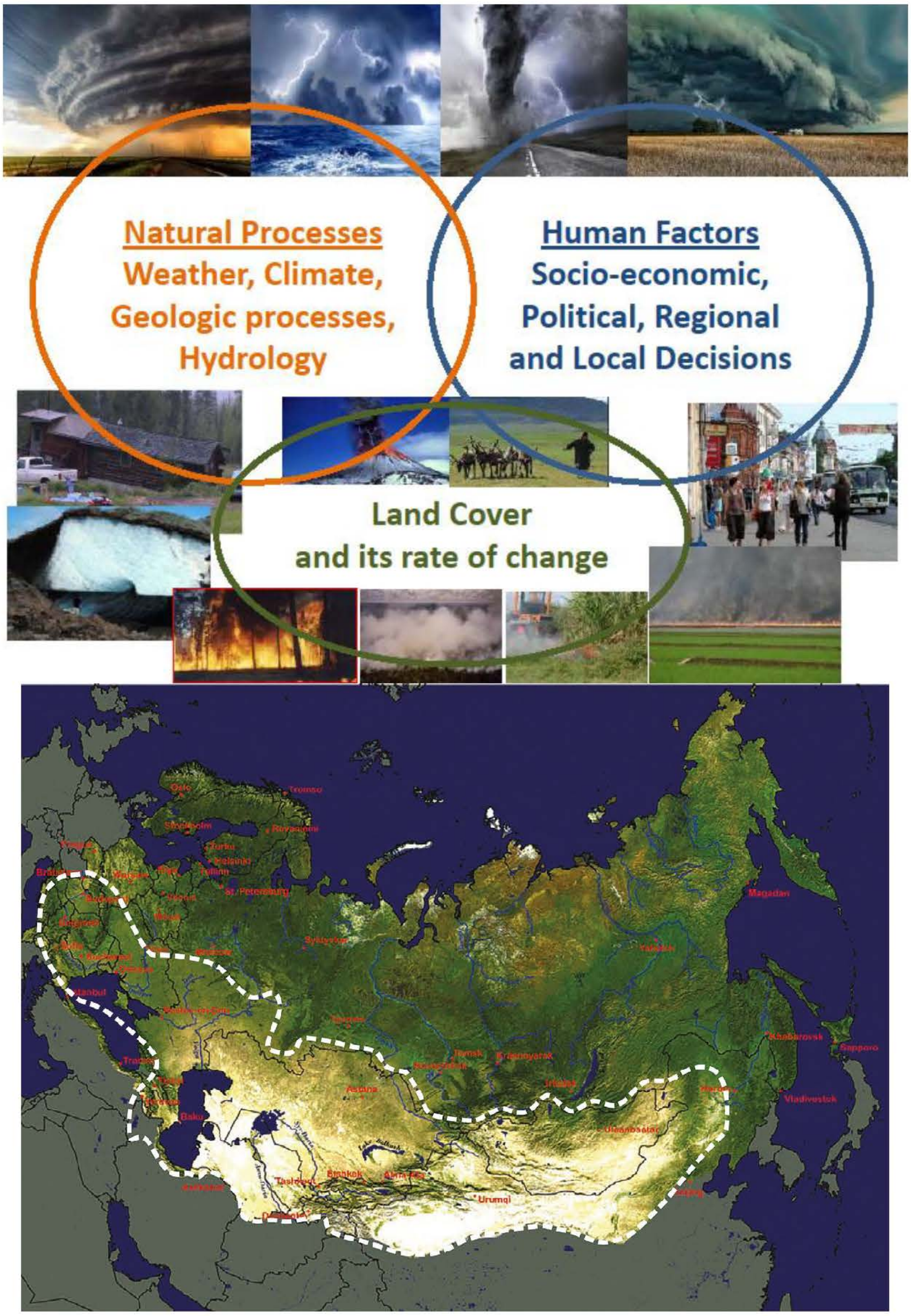
*Pavel Groisman[1,2,3], Garik Gutman[4], Sergey Gulev[2], Shamil Maksyutov[5], Jiaguo Qi[6]

1. University Corp. for Atmospheric Research Project Scientist at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA, 2. P.P.Shirshov Institute of Oceanology, RAS, Moscow, Russia, 3. Hydrology Science and Services Corporation, Asheville, North Carolina, USA, 4. NASA Headquarters, Washington, District Columbia, USA, 5. National Institute for Environmental Studies, Tsukuba, Japan, 6. Michigan State University, East Lansing, Michigan, USA

During the past 12 years, the Northern Eurasia Earth Science Partnership Initiative (NEESPI) –an interdisciplinary
program of internationally-supported Earth systems and science research –has addressed large-scale and long-term manifestations of climate and environmental changes over Northern Eurasia and their impact on the Global Earth system. With more than 1500 peer-reviewed journal publications and 40 books to its credit, NEESPI's activities resulted in significant scientific outreach. This created a new research realm through self-organization of NEESPI scientists in a broad research network, accumulation of knowledge while developing new tools (observations, models, and collaborative networks) and producing new, exciting results that can be applied to directly support decision-making for societal needs. This realm was summed up at the Synthesis NEESPI Workshop in Prague, Czech Republic (April 9-12, 2015) where it was decided to shift gradually the foci of regional studies in Northern Eurasia towards applications with the following major Science Question: "What dynamic and interactive change(s) will affect societal well-being, activities, and health, and what might be the mitigation and adaptation strategies that could support sustainable development and decision-making activities in Northern Eurasia?". To answer this question requires a stronger socio-economic component in the ongoing and future regional studies focused on sustainable societal development under changing climatic and environmental conditions, especially, under conditions when societal decision-making impacts and feeds back on the environment. This made the NEESPI studies closer to the ICSU research initiative "Future Earth". Accordingly, the NEESPI Research Team decided to reorganize in the nearest future NEESPI into "Northern Eurasia Future Initiative" (NEFI) and began development of its Programmatic White Paper (in preparation at the time of this abstract submission). The NEFI research foci emerged in discussions within the NEESPI community during the past 20 months. Presentation will provide justification of these foci and approach examples addressing them. The societal challenges, particularly the socio-economic challenges are the top priority in most of them.
Throughout the NEESP Initiative duration, support for it studies has been provided by different national and international Agencies of the United States (in particular, the NASA Land Cover and Land Use Change Program), the Russian Federation (in particular, the Ministry of Education and Science, e.g., mega-grant 14.B25.31.0026), European Union, Japan, and China. After the NEFI White Paper release, we anticipate a similar kind of support for this new Initiative.

Keywords: Northern Eurasia, Environmental change, NEESPI




**Top.** **Major natural and direct anthropogenic processes that affect Northern Eurasia (Soja et al. 2015).**
**Bottom.** **The NEESPI study domain. The Dry Latitudinal Belt of Northern Eurasia is sketched on the map by dashed white line.**

# Snow Cover Monitoring in Northern Eurasia

*Olga Bulygina[1,2], V. Razuvaev[1], P. Groisman[2,3]

1.All-Russian Research Institute of Hydrometeorological Information–World Data Centre, 6 Koroleva St., Obninsk, Kaluga Oblast’, 249035, The Russian Federation , 2.P.P. Shirshov Institute of Oceanology, 36 Nakhimovsky Ave., Moscow, 117997, The Russian Federation , 3.UCAR at NOAA National Centers for Environmental Information, 151 Patton Avenue, Asheville, North Carolina 28801, USA

Snow covers through its unique physical properties (high reflectivity and low thermal conductivity) and water storage, plays critical roles in energy and water exchanges, hydrology and the ground thermal regime. The main objective of this research is to monitoring snow cover change in Northern Eurasia. The annual surface air temperature in Northern Eurasia is increasing by 2.1 C/ 10 years during the period of 1936 to 2015. Close to the north in the Arctic Ocean, the late summer sea ice extent is decreasing providing a near-infinite source of water vapor for the dry Arctic atmosphere in the early cold season months. There is also evidence of more frequent thaw days over western Eurasia. All these factors affect the state of snow cover.
Changes of snow cover duration, snow depth and snow water equivalent are described.
Snow cover duration (SCD) decrease over several regions of European Russia, Western Siberia and the Atlantic and Siberia Arctic, while positive values of SCD trends are infrequent and randomly scattered. The maximum winter snow depth increases in the Atlantic Arctic, southern part of the forest zone of Western Siberia, central part of Eastern Siberia and Russian Far East. At the same time, the maximum winter snow depth decreases in southern European Russia, Altai and Sayany Mountains and Piedmont and Trans-Baikal regions. The largest change was documented for Trans-Baikal region, the decrease is 13 percent per decade. The increase of maximum winter snow water equivalent in the field is observed in Western Siberia, Sakhalin and eastern European Russia. In the south of the forest zone of Western Siberia, the water equivalent increase is 5 % in ten years. According to course observations in the forest, the decrease in maximum snow water equivalent for the winter is recorded over most of European Russia.
The work was supported by the Ministry of Education and Science of the Russian Federation (grant 14.B25.31.0026).

Keywords: Snow cover, snow cover duration, snow water equivalen, climate monitoring

# ELIMINATION OF ACCUMULATED ENVIROMENTAL DAMAGE IN THE RUSSION FEDERATION ARCTIC ZONE

*Bulygin Alexander[1], Yury Suchev[1]

1.Non-commercial Organization Polar Foundation

Protection of the environment is an essential condition for the stable development of the humankind. Elimination of accumulated environmental damage is a significant part of this global problem.
Research was conducted in accordance with the order of the Prime Minister of the Russian Federation dated June 10, 2010 "On approval of the package of measures to reduce and prevent negative impacts on the environment of the Arctic zone of the Russian Federation". Research was carried out at the Alexandra Land island, Graham-Bell island, Hooker island, Rudolfa island, Heysa island and Hoffmann island of Franz Josef Land archipelago.
Scientific research result an elaboration of a practical activity plan. The main stages of technological works on the elimination of accumulated environmental damage that were developed are:
Step1. Comprehensive ecological survey of the Franz Joseph Land wasted territories
Step 2. Logistic operation for delivery of the workers,supplies and equipment;
Step 3. The base camp organization for work on clean-up;
Step 4. Putting into operation of production equipment, getting the first results;
Step 5. Carrying out main works on the Islands;
Step 6. Removal of the collected waste to the “Big Land”;
Step 7. Summarizing the results of the executed works. The definition of plans for the next season.
For example, only for two years, only on the Franz Josef Land archipelago:
47411 drums were collected, cleaned and compacted with total weight of 1892 tons;
1744 tons of oil and fuel were collected and stored in the 50 cubic meter tanks;
2800 tons of other scrap metal were collected;
4797 tons of other waste products including wood, stones etc. were collected and stored;
34 hectares of oil-wasted land were remediated;
Alexandra Land Island is fully cleaned.
Fig1.The characteristic of pollution of the Franz Josef Land archipelago.

Keywords: environmental damage, Arctic zone