

## 10 Years of NEESPI Accomplishments and Future Plans Highlighted at Synthesis Workshop

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During the past 10 years, the Northern Eurasia Earth Science Partnership Initiative (NEESPI), a GEWEX Regional Hydroclimate Project (RHP), has addressed large-scale and long-term manifestations of climate and environmental changes over Northern Eurasia (north of 40°N) and their impact on the global Earth system. Originating from a bilateral U.S.-Russia program between the National Aeronautics and Space Administration (NASA) and the Russian Academy of Sciences (RAS), NEESPI has truly become an international research program with multi-agency support. The NEESPI Science Plan was prepared in 2004 by a team of more than 100 geoscientists from 11 countries (<http://neespi.org/science/science.html>). The Plan's Executive Summary was prepared in English, Russian, and Chinese and later published in Groisman and Bartalev (2007). Over the years, NEESPI progress has been reported in programmatic papers (e.g., Groisman et al., 2009, 2014; and Groisman and Soja, 2009), and several overview books (e.g., Gutman and Reissell, 2011; Groisman and Lyalko, 2012; Groisman and Gutman, 2013; and Chen et al., 2013).

The implementation of NEESPI has included 172 projects focusing on different environmental issues in Northern Eurasia, each of them typically lasting 3 years and funded by various national and international agencies. Over the years, NEESPI engaged more than 750 scientists from over 200 institutions in 30 countries. More than 80 Ph.D. students defended their theses while conducting their research within the NEESPI framework. The Initiative revitalized the scientific community working on Earth studies over Northern Eurasia by convening NEESPI sessions at many international meetings, including the American Geophysical Union, European Geosciences Union (EGU), and Japan Geoscience Union annual events, and by organizing more than 30 NEESPI workshops. Since 2009, two training sessions at early career scientists' summer schools were convened with the intent not only to share cutting edge science with young researchers, but also to cultivate a new generation of scientists.

NEESPI has created a new research realm through the self-organization of NEESPI scientists into a broad research network, accumulation of knowledge while developing new tools (observations, models and collaborative networks) and producing new knowledge, some of which can be directly ap-

plied to supporting decision making for societal needs. With more than 1480 peer-reviewed journal publications and 40 books to its credit, NEESPI's activities have resulted in significant scientific outreach.

### *NEESPI Synthesis Workshop*

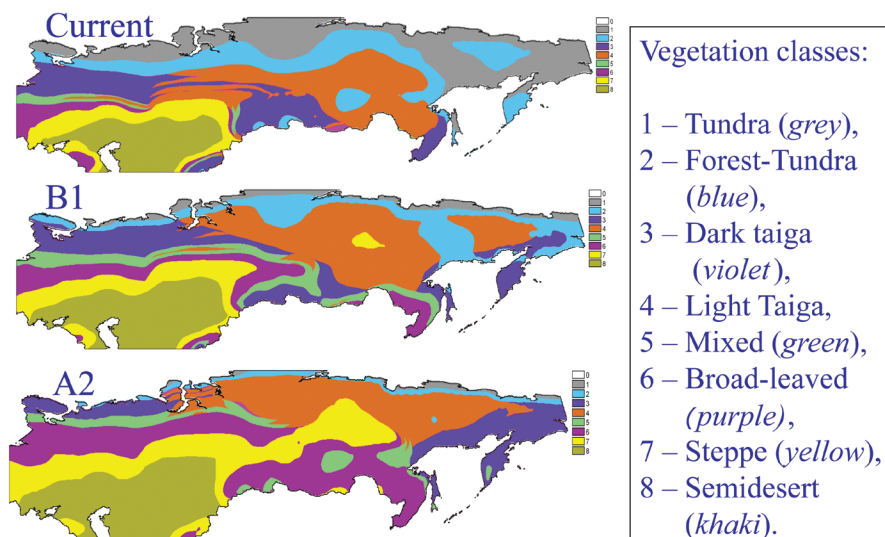
"Ten Years of NEESPI: Synthesis and Future Plans" was held at the Charles University in Prague, Czech Republic on 9–12 April 2015. The Workshop was organized and sponsored by NEESPI, the World Meteorological Organization, NASA, Charles University, P.P. Shirshov RAS Institute of Oceanology (Grant 14.B25.31.0026) and private companies. More than 70 invited participants from Japan, China, Russia, Ukraine, the European Union and the U.S. attended. Students from the Charles University were welcomed along with early career scientists who had attended the "Transatlantic Training in East European and Baltic Countries in the Area of Earth Observations," that was held in Prague in parallel with the Workshop.

The Workshop included overview synthesis lectures and science planning for the orderly transition of NEESPI to the Northern Eurasia Future Initiative (NEFI) Program (<http://neespi.org/meetings/>). Additionally, 18 posters were presented during the breaks. Results of the Workshop were delivered at the dedicated public splinter meeting held during the EGU Assembly in Austria on 16 April 2015. See: <http://neespi.org/web-content/PragueWorkshopSynthesisBriefing.pdf> and <http://neespi.org/web-content/PragueWorkshopOutreachPlans.pdf>.

Overview presentations at the Workshop included programmatic talks delivered by representatives of the NEESPI founding institutions. Drs. Gutman (NASA) and Georgiadi (RAS) discussed the NEESPI achievements over the past decade and how these organizations benefited from the project. R. Lawford highlighted the NEESPI role in GEWEX as one of its RHPs and discussed the potential links of future Northern Eurasia studies with the Group on Earth Observations (GEO) and Future Earth.

Studying biosphere dynamics in Northern Eurasia and understanding the impacts of the region's terrestrial ecosystems on the global carbon cycle have been key research efforts of NEESPI. Results, synthesis of international efforts, current assessment and future projections of biospheric changes in Northern Eurasia were presented in overview talks by H. Shugart, A. Shvidenko, M. Heimann and A. Soja, as well as in poster presentations by V. Kharuk and E. Kukavskaya. It was shown that biospheric changes have already become visible and their projections (see figure on page 11) hint at the continental-wide shifts in ecosystems with global consequences on carbon, energy and water cycles. Furthermore, terrestrial water cycle and cryosphere changes over Northern Eurasia have strong interactions with the regional carbon cycle. Overviews of these interactions and the projections of their changes were provided in presentations by D. Lettenmaier and V. Romanovsky.

Northern Eurasia is one of the largest land masses and the only one that is substantially isolated from the tropical air masses by mountain ranges and plateaus in the center of the



Vegetation distribution over Northern Eurasia in current climate and by the year 2090 calculated by the RuBCLiM ecosystem model (archive of Shuman et al., 2015) using the Coupled Model Intercomparison Project Phase-5 ensemble global circulation model output for B1 and A2 scenarios (i.e., for corresponding greenhouse gases induced global warming to 2090 by 3–5°C and 6–8°C).

continent. Water supply into the western three quarters of this region is provided by extratropical cyclones that come with the westerlies. This is an unstable source and droughts and floods frequently occur here with any deviation of the “normal” flow of weather events. The distribution and frequency of these extreme events have recently changed. S. Gulev’s synthesis of extreme weather events over Northern Eurasia showed that changes in the seasonal cycle, particularly the earlier spring onsets and depletion in the frozen water storage (glaciers, seasonal snow cover and permafrost), lead to a longer warm season and exaggerate the strength and duration of extreme events in this season.

The NEESPI research domain can be loosely partitioned into northern (the Arctic and boreal zones) and the Dry Latitudinal Belt of Extratropical Eurasia (DLB; see figure on next page). NEESPI research shows that the boundary between two parts of this domain is dynamic, has changed in the past, and most probably will change in the near future (see figure above). Changes in terrestrial cryosphere may reshape the landscapes of the Arctic due to permafrost thaw and internal continental dry regions related to the growing water deficit (weaker westerlies and retreating glaciers). The reshaping has already affected socio-economic systems in the Arctic (reported by N. Shiklomanov) and in the DLB (reported by J. Qi). In the latter, the natural dangers from inclement weather overlap with growing direct anthropogenic pressure on ecosystems. Population growth and economic development in large parts of DLB are considered more a cause concern than changes to the climate. The growing demand to expand and redirect research in Northern Eurasia, from studying mostly physical

processes to investigating the consequences of their changes, became a driving force in the development of new approaches and foci within the NEESPI successor, NEFI. Interactions of environmental changes (natural and human-induced) with societal activity have not been well covered in past NEESPI studies. However, these studies are gradually moving to the forefront of regional research due to vulnerability of the regional environment triggered there by both intensification of human activity and climatic changes that are among the largest in the world.

Synthesis of hydrological, biospheric, cryospheric, climatic and socio-economic models within a suite of interactive models empowered by expanded observational input remains a key tool for understanding and projecting dynamics in Northern Eurasia (Kicklighter et al., 2014). Presentations by Q. Zhuang, D. Kicklighter, and E. Monier examined the role of Earth system modeling with foci on Northern Eurasia. Synthesis of the current state of these models, their perspectives and their deliverables (projections) were discussed.

### Future Research Directions

Nine NEFI research foci emerged in discussions within the NEESPI community during the past 12 months and a consensus was reached at the Workshop.

1. Global change, particularly the warming of the Arctic
2. Increasing frequency and intensity of extremes (intense rains, floods, droughts, and wild fires)
3. Retreat of the cryosphere (snow cover, sea ice, glaciers and permafrost)
4. Changes in the terrestrial water cycle (quantity and quality of water supply available for societal needs)
5. Biosphere changes (ecosystem shifts, changes in the carbon cycle, land cover degradation and dust storms)
6. Pressure on agriculture and pastoral production (growing demand, changes in land use and food security)
7. Changes in infrastructure (roads, new routes, construction codes, air, water and soil pollution, and strategic planning)
8. Societal actions to mitigate negative consequences of environmental changes and to benefit from positive consequences
9. Quantification of the role of Northern Eurasia in the global Earth and socioeconomic systems to advance research tools with an emphasis on observations and models





The NEESPI study area is loosely defined as the region between 15°E in the west, the Pacific Coast in the east, 40°N in the south, and the Arctic Ocean coastal zone in the north. The green corresponds to vegetated land and the light brown and yellow indicate sparse vegetation and arid areas, respectively. The Dry Latitudinal Belt of Northern Eurasia is sketched on the map by the dashed white line (Groisman et al., 2009).

It was noted that during the past decade, the global Earth system has changed significantly, with changes in Northern Eurasia being substantially larger than the global average (Groisman and Gutman, 2013; Karl et al., 2015). However, not all components of the Earth system follow global trends. Current analyses show unexpected features and distributions, from shifts of the seasonal cycle in various climatic characteristics to changes in intensity, frequency and spatial and temporal distributions of extreme events. These changes have already occurred but their impacts on (and feedbacks to) several components of the Earth system are ongoing. In many aspects, this may be transitional but their development (especially the role of human activity) may define the future trajectory of regional changes and their feedbacks. This is especially important because socio-economic situations in the major nations of Northern Eurasia have significantly changed, including their abilities to withstand and adapt to adverse manifestations of environmental change.

The primary NEESPI science question was: “How do Northern Eurasia’s terrestrial ecosystem dynamics interact with and alter the biosphere, atmosphere and hydrosphere of the Earth?” For NEFI, this question has been expanded to: “What will the changes in these dynamics and interactions mean for societal well-being, activities, health and decision making?” The legacy of NEESPI is in its established connections, the ongoing synthesis of previous studies and the new generation of scientists that emerged from the NEESPI projects. We know much more, we acquired new tools (observations and models) and we can gradually switch from scientific research to developing applications that directly address societal needs.

Moreover, during the past decade, further climate and environmental changes have occurred, some of which now require direct responses on behalf of societal well being and human health.

After the Workshop, the Initiative groups began preparation of three documents: (1) a topical review paper to be published in the *Environmental Research Review Letters*; (2) a succinct paper for a strong impact journal with key NEESPI findings and planned NEFI work; and (3) a white paper entitled “Northern Eurasia: Facing the Challenges and Pathways of Global Change in the 21<sup>st</sup> Century” that will be distributed across the international science institutions and national sponsoring agencies.

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