Meeting Summary

Grand Challenges in Earth Science

The Weather–Climate–Society Nexus over Northeast Asia

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1st Joint Workshop on the A3 Foresight Program Workshop: “Networking Climate Change Hubs for Promoting Future Earth over Northeast Asia”

What: After the pandemic, 39 climate and environmental scientists from three Northeast Asian countries, South Korea, China, and Japan, participated the 1st A3 Foresight Program Workshop to share and discuss with over 270 participants recent progress in research of climate changes, extreme weather events, aerosol–climate interactions, and the socioeconomic impacts on communities over Northeast Asia.

When: 18–19 April 2023

Where: Busan, South Korea
northeast Asia (NEA) includes the Mongolian Plateau, the Northeast China Plain, the Korean Peninsula, the Japanese Archipelago, and the mountainous regions of the Russian Far East, comprising 300 million people (5% of the world population; Guo 2012). With rapid population growth and social and economic development, human activities over NEA have played a role in climate change, accounting for 31.5% of the world’s greenhouse gas (GHG) emissions in 2018 (UN Environment Programme 2021). The growing impact of human activities on the regional and global climate systems remains uncertain.

A wide range of studies has been conducted in Northeast Asia, focusing on climate changes, extreme weather events, aerosols, and socioeconomic impacts in the region as part of the international Future Earth initiatives. However, the three-year-long COVID-19 pandemic has caused the doldrums of international collaboration activities about climate change and extreme climate impacts on Northeast Asia’s environment. To reactivate international collaborations among Northeast Asia’s climate and other Earth science discipline scientists, the 1st Joint Workshop on the A3 Foresight Program was held at the Busan Exhibition and Convention Center (BEXCO) in Busan, South Korea, over 18 and 19 April 2023. This two-day workshop was sponsored by Japan Society for the Promotion of Science, National Natural Science Foundation of China, and National Research Foundation of Korea and was hosted by the Korean Meteorological Society as a special co-session of the 60th Korean Meteorological Society Spring Meeting. The theme of the workshop was “Grand Challenges in Earth Science: The Weather–Climate Society Nexus over Northeast Asia.” The workshop consisted 39 oral (35 in-personal oral + 4 virtual oral) and 3 poster presentations represented by Chinese, Japanese, and Korean scientists under the four focused topics (Fig. 1).

Paleo and future perspectives on climate changes over Northeast Asia

Scientists have presented their recent studies that explored climate changes in Northeast Asia by analyzing paleoclimate records and modeling future scenarios. These studies revealed evidence of past climatic fluctuations and teleconnections (Xu et al. 2022), including shifts in large-scale circulations, temperature and precipitation anomalies, and monsoon intensities (Hu et al. 2021; Sharma et al. 2023). A study about heavy rainfall events was introduced using a 20-km nonhydrostatic regional climate model whose boundary conditions were from global climate model large ensemble simulations (Imada et al. 2020). The event attribution analysis of two heavy rainfalls over western Japan in 2017 and 2018 from these high-resolution downscaled projections concluded that success of risk-based event attribution for regional extreme rainfall depends on how much the uncertainty induced by the dynamic components is reduced by background conditions. An event attribution study of the
2020 summer exceptionally persistent rainfall over eastern Asia, including south-central and eastern China and western Japan, was introduced based on the 525 ensemble “actual” and “counterfactual” simulations of the 50-km HadGEM3-GA5 global climate model (Tang et al. 2022). The long-lasting 2020 summer pluvial events over eastern Asia were likely caused by the northwestern Pacific anomalous anticyclone and La Niña–induced Walker circulation intensification with little contribution of anthropogenic influence due to the compensation effect between the greenhouse gases and anthropogenic aerosol forcings.

Large uncertainties in climate and Earth system models were discussed from the perspective of interactions with internal variability and external forcing (Chen et al. 2020; Gong et al. 2022). A recent study using a fractional integral statistical model was introduced to capture a realistic warming signal to bypass “hot model” problems that may be attributed to overestimated memory of the Earth climate system (Yuan et al. 2022).

**Asian monsoons and extreme weather in a changing climate**

Researchers have investigated the behavior of Asian monsoons and their connection to extreme weather events in the context of a changing climate. They have found that climate change can influence monsoon dynamics, leading to changes in precipitation patterns, intensity, and the occurrence of extreme events, such as droughts, floods, and heatwaves, over the northeastern Asia. The responses of regional hydroclimatic extremes over eastern Asia to the CO₂
pathways were introduced (Jo et al. 2022). Under a symmetric ramp-up and -down of CO₂ concentra-
tions, the ramp-down period had a higher frequency of long-lasting heavy rainfall days
than the ramp-down period, which led to a hysteresis response. Delayed teleconnections be-
tween the northern Indian Ocean and precipitation over northeastern Asia were also introduced
(Kim and Kug 2021). The northern Indian Ocean warming in June caused one-month delayed
cold anomalies over the Korean Peninsula and Japan via the resultant Kelvin wave–induced
Ekman divergence over the western North Pacific. Possible future climate scenarios over
the Korean Peninsula and Japan were discussed from the perspective of interactions of
delayed SST teleconnections and global warming.

A concept of dry and moist heatwaves was introduced (Fig. 2; Ha et al. 2022). Heatwaves
were classified into dry and moist heatwaves based on near-surface humidity below 33%
and above 66% during the heatwave occurrence. The concept was implemented to under-
stand the generating mechanisms and investigate the risk of these two types of heatwaves
over East Asia. While dry heatwaves were amplified by anticyclonic circulations due to
the convergence of anomalous wave activity flux over northern East Asia, cloud and water
vapor feedback amplified moist heatwaves, local anticyclonic anomalies, and the surface
warming. (Fig. 2). Intensification of dry heatwaves and increased moist heatwave days were
expected in a CO₂-enriched warming environment. These three and other presentations

Fig. 2. Trends of (a) dry and (b) moist heatwaves and observed near-surface temperature and relative humidity during (c) dry and
(d) moist heatwaves [see Fig. 1 in Ha et al. (2022)].
underscored the need for improved understanding and prediction of monsoon behavior to enhance preparedness and adaptation strategies over the eastern Asia.

**Changes in aerosols and interactions with climate change**

Studies have examined the impacts of changing aerosol concentrations in Northeast Asia and their interactions with climate change. Aerosols can influence regional climate by affecting cloud formation, solar radiation, and precipitation patterns at multiscales (regional-to-continental scales). Synergic effects of global warming and anthropogenic aerosols on meteorological conditions and atmospheric compositions over eastern Asia were introduced (Ryu and Min 2022). A strong temperature increasing trend in northwestern Mongolia, the extended western North Pacific subtropical high, and anomalous anticyclonic circulation over the East China Sea provided such a favorable drought condition over the southeastern China region that more anthropogenic aerosols caused more cloud droplets and larger cloud optical depths, leading to reduced solar radiation and thus lower temperature. This near-surface condition likely drives a stronger stability and weaker updraft. Research has highlighted the complex interactions between aerosols, atmospheric circulation, and monsoon systems in Northeast Asia, emphasizing the importance of accurate representation of aerosol dynamics in climate models to improve projections and mitigation strategies.

**Socioeconomic impacts of climate change on Northeast Asian communities**

Investigations into the socioeconomic impacts of climate change on Northeast Asian communities have shed light on the vulnerabilities and adaptive capacities of different sectors. Researchers have examined the consequences of changing climate patterns on agriculture, coastal areas, urban centers, vulnerable ecosystems, and populations in Northeast Asia. The global assessment of economic damage functions for weather and climate extremes were introduced via the coupled natural–human system (Franzke 2021). The global economic damage data showed that Europe is the most affected continent followed by North America and Asia. According to nonstationary probabilistic models, exposed population is a significant factor of the economic damage from extreme weather and climate events. Another recent study (Katazakai and Zhang 2021) reported the 25-yr decreasing trend of nutrient load reductions caused by the government adopted new wastewater treatment systems in 1993. This decrease of nutrient loads resulted in halving river-in nutrient fluxes and thus increasing phosphorus deficiencies in the coastal waters of Toyama Bay in central Japan. This study also emphasized the need to conduct various case studies over different areas across the Northeast Asia countries to deepen our understanding of land–sea interactions via hydrological and nutrient cycles. Another study introduced the observed ecological shift of the endangered black-faced spoonbill (*Platalea minor*) over four habitats along the coastal lines of the Korean Peninsula (Jeong et al. 2021). This study examined stable isotopes ($\delta^{13}C$, $\delta^{15}N$) between the tip (grown at the age of 10 days) and middle (grown at the age of 22 days) portions of their primary feathers. This study highlighted the value of freshwater wetlands for spoonbills on offshore islands without an inflow of freshwater in nearby intertidal mudflats. The studies presented in the theme of “Socioeconomic impacts of climate change on Northeast Asian communities” underscored the need for holistic approaches that integrate climate science with socioeconomic factors to develop effective adaptation and mitigation strategies tailored to the specific needs of communities in Northeast Asia.

**Challenges for the post-COVID-19 pandemic era**

Around 300 junior and senior scientists from China, Japan, and South Korea participated in the 1st Joint Workshop on the A3 Foresight Program Workshop, sharing valuable insights on climate changes, extreme weather events, aerosol–climate interactions, and the socioeconomic
impacts on communities over the NEA region (Fig. 1b). The success of this workshop was rooted in the initiative effort of senior scientists that have learned the value and importance of international networking on their scholarly productivity from their past experience and the willingness of junior scientists to develop their own international network across the countries over Northeast Asia. Bureaucratic processes of the visa for international workshops and conference have been more complicated than before the COVID-19 pandemic, which was a challenge for the program committee. During this workshop, junior scientists and graduate students were most beneficil from the 39 oral presentations. They developed the knowledge of recent progress across the disciplines and build up their own international networks with scientists from other countries. Particularly, air pollution issues over Northeast Asia have been a hot potato since the sources of air pollutants and the transporting mechanisms are still under debate among scientists across the Northeastern Asia countries. This international workshop reinforced the value of in-person interactions among senior and junior scientists from China, Japan, and South Korea and provided an invaluable opportunity to discuss international environmental issues. As part of the multiyear grant activities, the 2nd A3 workshop will be held in Zhuhai, Guangdong Province, China (18–20 December 2023).

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References