Japanese Integrated and Collaborative Research Activities on Impact Assessment of Climate Change on Natural Hazards, Water Resources, and Ecosystems Towards Building an Adaptation Strategy

Eiichi Nakakita[1]

[1]Disaster Prevention Research Institute, Kyoto University, Uji, Kyoto 611-0011, Japan
Email: nakakita@hmd.dpri.kyoto-u.ac.jp

Not long ago, there was a great deal of careful discussion on whether or not global warming is related to extreme weather phenomena such as the large typhoons and localized heavy rainfall that have been increasing recently. However, Japan experienced any number of close brushes with, and direct hits from, large typhoons and frequent occurrence of strong winds, floods, overflowing rivers, high tides, high waves, and landslides. Concern has spread that these disasters may intensify as global warming progresses.

Theme D, precise impact assessments on climate change, under the program for risk information climate change (SOUSEI program) supported by MEXT, aims to scientifically demonstrate the connection between the aforementioned increase in natural hazards and global warming and to look 100 years into the future to see how serious it may become. The research results are to be presented as "actual figures" and are expected to be used as data for the government and municipalities to consider how to protect the lives of people in urban and rural areas, coastal areas, and river areas.   A "100 year impact assessment" was proposed by this program's antecedent, KAKUSHIN, but this is the first attempt to produce an actual figure for "the maximum predicted amount of future rainfall." To generate this kind of specific figure, detailed data with a high degree of precision is required. Even with all the data that we can collect, the sample size and precision are still inadequate. So, in Theme D, we take on the challenge of developing an assessment model that can produce predictions even given the data limitations, and we endeavour to assess extreme phenomena.   Broadly speaking, there are three specific research sub-themes. They are "climate change impacts on natural hazards," "climate change impacts on water resources," and "climate change impacts on ecosystems and biodiversity.

The first sub-theme, climate change impacts on natural hazards, is handled by DPRI-KU, together with Global Centre of Excellence for Water Hazard and Risk Management (ICHARM/PWRI). We aim to produce predictions for scenarios including worst-case particularly in the case of typhoons, which cause the most serious weather-related damage in Japan, concerning the frequency, scale, accompanying precipitation, strong winds, high tides, and high waves, including during the Baiu season.

The second sub-theme, climate change impacts on water resources, is handled by DPRI-KU and IIS in the University of Tokyo. When the climate changes due to global warming, the rain amount and rain patterns change significantly. It is also possible that what formerly fell as snow will change into rain. In Japan which has many mountainous regions, it is anticipated that this would cause a great change in the "pattern of water flowing into rivers."   So, Kyoto University team of this group will predict and assess the changes in the flow and supply of water in the main rivers in Japan, the impact on rice farming, etc., and the need for flood control such as dams, etc. Similar prediction and assessment will be pursued for the world's major rivers, including in Asia. The University of Tokyo team will predict and assess how the actual water cycle will change on a global scale with the addition of artificial modifications. This team will also study the effectiveness of adaptation strategies.

The third sub-theme, climate change impacts on ecosystem and biodiversity, is supervised primarily by Graduate School of Life Sciences at Tohoku University, and other

participants include Nagoya University, Hokkaido University and NIES. We aim to predict and assess whether ecosystems are capable of changing abruptly due to global warming, taking as models the forests of northeastern Japan and the marine life in the ocean near Japan. The Tohoku University team will conduct predictions and assessments concerning whether global warming will cause the extinction of alpine plants, the impact of strong wind on forests, the purification effects of forests, and changes in tourism resources. The Nagoya University team will conduct predictions and assessments on how climate change alters forest vegetation and then whether the altered forest vegetation affects the climate. The main research sites will be Asian rainforests and the eastern boreal Siberia. The team will study the changes in the major forests in the world, such as the tundra forest. The team composed of Hokkaido University and NIES focus on ocean acidification which occurs when more anthropogenic carbon dioxide dissolves in seawater. The team will predict and assess what sorts of changes will occur in coastal marine ecosystem such as coral reefs and seaweed forests due to global warming and ocean acidification.

REFERENCES

Over all

Kitoh, A., T. Ose, K. Kurihara, S. Kusunoki, M. Sugi, and KAKUSHIN Team-3 Modeling Group, 2009: Projection of changes in future weather extremes using super-high-resolution global and regional atmospheric models in the KAKUSHIN program: Results of preliminary experiments. Hydro. Res. Lett., 3, 49-53.

Mizuta, R., H. Yoshimura, H. Murakami, M. Matsueda, H. Endo, T. Ose, K. Kamiguchi, M. Hosaka, M. Sugi, S. Yukimoto, S. Kusunoki, and A. Kitoh, 2012: Climate simulations using MRI-AGCM3.2 with 20-km grid. J. Meteor. Soc. Japan, 90A, 233-258, doi:10.2151/jmsj.2012-A12.

Kitoh, A., and H. Endo, 2016: Changes in precipitation extremes projected by a 20-km mesh global atmospheric model. Weather and Climate Extremes. 11, 41-52, doi: 10.1016/j.wace.2015.09.001

Mizuta, R., O. Arakawa, T. Ose, S. Kusunoki, H. Endo and A. Kitoh, 2014: Classification of CMIP5 future climate responses by the tropical sea surface temperature changes. SOLA, 10, 167-171, doi:10.2151/sola.2014-035.

Natural Hazards

Ito, R., T. Takemi, and O. Arakawa, 2016: A possible reduction in the severity of typhoon wind in the northern part of Japan under global warming: A case study. SOLA, 12, 100-105, doi:10.2151/sola.2016-023.

Mori, N., and T. Takemi, 2016: Impact assessment of coastal hazards due to future changes of tropical cyclones in the North Pacific Ocean. Weather and Climate Extremes, 11, 53-69, doi:10.1016/j.wace.2015.09.002.

Takayabu, I., K. Hibino, H. Sasaki, H. Shiogama, N. Mori, Y. Shibutani, T. Takemi, 2015: Climate change effects on the worst-case storm surge: a case study of Typhoon Haiyan. Environ. Res. Lett., 10, 064011, doi:10.1088/1748-9326/10/6/064011

Oku, Y., J. Yoshino, T. Takemi, and H. Ishikawa, 2014: Assessment of heavy rainfall-induced disaster potential based on an ensemble simulation of Typhoon Talas (2011) with controlled track and intensity. Natural Hazards and Earth System Sciences, 14, 2699-2709, doi:10.5194/nhess-14-2699-2014.

Ishikawa, H., Y. Oku, S. Kim, T. Takemi, and J. Yoshino, 2013: Estimation of a possible maximum flood event in the Tone River basin, Japan caused by a tropical cyclone. Hydrological Processes, 27, 3292-3300, doi: 10.1002/hyp.9830.

Sato, Y., Kojiri, T., Michihiro, Y., Suzuki, Y. and Nakakita, E. (2013), Assessment of climate change impacts on river discharge in Japan using the super-high-resolution MRI-AGCM. Hydrol. Process., 27: 3264–3279. doi: 10.1002/hyp.9828

Oku, Y. and Nakakita, E. (2013), Future change of the potential landslide disasters as evaluated from precipitation data simulated by MRI-AGCM3.1. Hydrol. Process., 27: 3332–3340. doi: 10.1002/hyp.9833

Takayabu, I., K. Hibino, H. Sasaki, H. Shiogama, N. Mori, Y. Shibutani and T. Takemi (2015)Climate change effects on the worst-case storm surge: a case study of Typhoon Haiyan,Environmental Research Letters, Vol.10, 064011.

Jiang, X, N. Mori, H, Tatano, L. Yang and Y. Shibutani (2015), Estimation of property loss and business interruption loss caused by storm surge inundation due to climate change; A case of Typhoon Vera revisit, Natural Hazards, pp.1-15.

Hemer, M.A., Y. Fan, N. Mori, A. Semedo and X.L.Wang (2013) Projected changes in wave climate from a multi-model ensemble, Nature Climate Change, 6p., doi:10.1038/nclimate1791.

Water Resources

Ishida, H., Kobayashi, S., Kanae, S., Hasegawa, T., Fujimori, S., Shin, Y., Honda, Y. (2014). Global-scale projection and its sensitivity analysis of the health burden attributable to childhood undernutrition under the latest scenario framework for climate change research. Environmental Research Letters, 9(6), 064014. doi:10.1088/1748-9326/9/6/064014

Kojima, H., Shida, T., Ishida, H., Niwa, H., Sumi, T., Inoue, M. : Evaluation of the value of hydropower generation and assessment of new development using existing dam reservoirs, Proc. of the 7th International Conference on Water Resources and Environmental Research (ICWRER2016), 2016.

Kotsuki, S., K. Tanaka, T. Kojiri : Estimation of Climate Change Impact on Japanese Water Resources Part 1: The development of a Japanese Water Resource Model, J. Japan Soc. Hydrol. and Water Resour.Vol. 26, No.3, pp.133-142, 2013. doi: 10.3178/jjshwr.26.133 (in Japanese)

Kotsuki, S., K. Tanaka, T. Kojiri : Estimation of Climate Change Impact on Japanese Water Resources Part 2: Water Demand-Supply Balance, Rice Yield Changes, and an Adaptation Plan, J. Japan Soc. Hydrol. and Water Resour.Vol. 26, No.3, pp.143-152, 2013. doi: 10.3178/jjshwr.26.143 (in Japanese)

Masumoto, Takao, 2016: Water Resources, Floods and Agro-Environment in Monsoon Asia: description and future applications of the DWCM-AgWU model, "The Challenges of Agro-Environmental Research in Monsoon Asia". NIAES Series No.6, National Institute for Agro-Environmental Sciences, 203-224.

Nohara, D., H. Miki, T. Hori, 2013: Impact analysis of long-term stochastic inflow prediction and its uncertainty on reservoir operation during drought situation, in Considering Hydrological Change in Reservoir Planning and Management, IAHS Publications, 362, pp.83-90.

Oki, T., 2015: Integrated Water Resources Management and Adaptation to Climate Change. International Journal of Water Resources Development, 31, accepted.

Sato, Y., M. Honma, Y. Suzuki, K. Tanaka and E. Nakakita, 2013 : Assessment of climate change impact on river discharge in cold and mountainous region in Japan, IAHS Publ., Vol.360, pp.125-130

Schewe J., Heinke J., Gerten D., Haddeland I., Arnell N. W., Clark D. B., Dankers R., Eisner S., Fekete B. M., Colón-González F. J., Gosling S. N., Kim H., Liu X., Masaki Y., Portmann F. T., Satoh Y., Stacke T., Tang Q., Wada Y., Wisser D., Albrecht T., Frieler K., Piontek F., Warszawski L., Kabat P. : Multimodel assessment of water scarcity under climate change, PNAS 201222460 (2013), doi:10.1073/pnas.1222460110

Tanoue, M., Watanabe, S., Tsunekawa, T., Hanasaki, N., Hirabayashi, Y. : Globa Il Water Resources Assessment Including Glacier Meltwater from Mountainous Regions, Journal of JSCE, B1, 71(4), I_451-I_456, 2015. (in Japanese)

Biodiversity and Ecosystems

Fan M & Shibata H. (2015) Simulation of watershed hydrology and stream water quality under land use and climate change scenarios in Teshio River watershed, northern Japan. Ecological Indicators 50:79–89.

Fan M, Shibata H, Wang Q. (2016) Optimal conservation planning of multiple hydrological ecosystem servicePs under land use and climate changes in Teshio river watershed, northernmost of Japan. Ecological Indicators 62: 1–13.

Imamura, K., Takano, K., Mori N., Nakashizuka T., and Managi S. "Attitudes toward disaster-prevention risk in Japanese coastal areas: Analysis of civil preference", Natural Hazards (in press).

Li Y, Tada F, Yamashiro T, Maki M. (2016) Long-term persisting hybrid swarm and geographic difference in hybridization pattern: genetic consequences of secondary contact between two Vincetoxicum species (Apocynaceae-Asclepiadoideae). BMC Evolutionary Biology 16: 20.

Miura A & Urabe J. (2015) Spatial and seasonal changes in species diversity of epilithic fungi along environmental gradients of a river. Freshwater Biology, 60:673–685.

Oguro M, Imahiro S, Saito S, Nakashizuka T. (2015) Relative importance of multiple scale factors to oak tree mortality due to Japanese oak wilt disease. Forest Ecology and Management 356: 173–183.

Takao, S., H. Yamano, K. Sugihara, N. H. Kumagai, M. Fujii, and Y. Yamanaka (2015), An improved estimation of the poleward expansion of coral habitats based on the interannual variation of sea surface temperatures, Coral Reefs, 34, 1125-1137, doi:10.1007/s00338-015-1347-2.

Fukuda, Y., and M. Fujii (2015), Biomass Resource Mapping and Potential Evaluation in Hokkaido, Japan, Journal of the Japan Institute of Energy, 94, 1057-1065.

Takao, S., N. H. Kumagai, H. Yamano, M. Fujii, and Y. Yamanaka (2015), Projecting the impacts of rising water temperatures on the distribution of seaweeds around Japan under multiple climate change scenarios, Ecology and Evolution, 5, 213-223, doi:10.1002/ece3.1358.

Yara, Y., M. Vogt, M. Fujii, H. Yamano, C. Hauri, M. Steinacher, N. Gruber, and Y. Yamanaka (2012), Ocean acidification limits temperature-induced poleward expansion of coral habitats around Japan, Biogeosciences, 9, 4955-4968, doi:10.5194/bg-9-4955-2012.