ISEC 2015

Integrating Research and Education to Study Severe Weather and Climate Variability

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The International Symposium on Earth-Science Challenges (ISEC) 2015 is the fourth summit to highlight the partnership between Kyoto University (KU) and the University of Oklahoma (OU). These biannual symposia are held alternately between Kyoto, Japan, and Norman, Oklahoma, to share recent research and education advances in the Earth sciences and to promote Japan–U.S. cooperation in this field. Natural disasters are inherently interdisciplinary, but the lines of research conducted to address their various aspects are often disconnected. The ISEC symposia build on the assets of the Norman campus and KU in observations, modeling, prediction, and social sciences to promote interdisciplinary education and research on natural disasters with the goal of building a resilient society.

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THE FOURTH INTERNATIONAL SYMPOSIUM ON EARTH-SCIENCE CHALLENGES (ISEC)

WHAT: More than 100 scientists, engineers, and students met to address the challenges in climate variability and extreme weather to build an integrative vision from multiple disciplines involving observations, numerical modeling, prediction, and social sciences.
WHERE: Norman, Oklahoma
WHEN: 20–23 September 2015

KU currently has multidisciplinary programs called Global Centers of Excellence (GCE) that focus on sustainability and resilience, while the research direction at OU emphasizes weather, radar, water, and climate. ISEC gathers these broad academic disciplines to foster interactions among topical areas at their intersection. Attendees have the opportunity to address scientific challenges with diverse academic methods and approaches. This approach is particularly beneficial for students (about a third of the 100 participants), who gain a broad perspective on the challenges and cutting-edge approaches, a potential to initiate new research directions across the worldwide scientific community, and in some cases have their first international experience. Previous ISEC symposia addressed challenges in climate variability and extreme weather through observations with innovative sensor technology as well as numerical modeling, assimilation, and prediction. ISEC 2015 highlighted the foundational dimension of risk as a multidisciplinary and integrating endeavor.

The fourth ISEC was dedicated to Dr. Yoshi Kazu Sasaki, one of the founding fathers of the Meteorology program at OU, who made numerous contributions to cultural, economic, and academic interactions between Japan and the state of Oklahoma. The symposium celebrated these accomplishments and also Sasaki's scientific contributions including his seminal contributions to the development of variation data assimilation (e.g., Lewis and Lakshmivarahan 2008).

The meeting was organized by the Disaster Prevention Research Institute (DPRI) and the Research Institute for Sustainable Humanosphere (RISH) of KU and the Advanced Radar Research Center (ARRC) and the College of Atmospheric and Geographic Sciences (CAGS) of OU, with participation of the National Oceanic and Atmospheric Administration (NOAA). The symposium was structured around a series of oral and poster presentations, with keynote presentations from researchers and practitioners in interdisciplinary science. To enhance the benefit of the collaboration and broaden the Japanese and U.S. student experience, short courses taught by professors from OU and KU were organized to expose students to topics not taught at their own universities, covering such diverse topics as hydrology and climate change, decision-making in the context of uncertainty, radar hydrology, and the recent Plains Elevated Convection at Night (PECAN) field campaign that took place over the Great Plains of the United States. The courses were complemented by visits to facilities, such as the Radar Innovations Laboratory, the National Weather Center, and weather radars in Norman.

RISK AS A FOUNDATIONAL DIMENSION IN ISEC 2015. Risk assessment is an essential dimension to understand, forecast, and mitigate natural disasters. Every discipline involved in ISEC 2015 confronts the challenges of understanding, quantifying, managing, and ultimately mitigating risk in some manner, but surprisingly few of them actually work collectively to study risk from a truly integrative perspective. Observation, numerical modeling, assimilation, and prediction individually aim at improving the state of knowledge of natural phenomena by increasing the information content yielded by sensors and models. The information has been traditionally conveyed in a deterministic, product-centric fashion of limited communication efficiency. These information gaps have been the basis for decade-long challenges within and across disciplines that impact natural hazard assessment and severe weather forecasting. It is now recognized that uncertainty assessment or probabilistic information are necessary to build on the primary information content provided by sensors and models to describe the state of understanding for the risk decision process. The question of how to efficiently and effectively communicate our uncertainty along with our knowledge on phenomena is still outstanding (Beven 2010). Moving from deterministic to probabilistic models, information, and practices requires a cultural shift to overcome long-standing challenges of the communication of risk and uncertainty within and across communities.

A keynote presentation by L. Rothfusz (NOAA/National Severe Storms Laboratory) illustrated this growing trend with NOAA's new operational Forecasting a Continuum of Environmental Threats (FACETs) project (Rothfusz et al. 2014). FACETS aims to provide rapidly updating and localized weather hazards information based on the probabilities of occurrence of a severe weather event. The project proposes an end-to-end holistic monitoring and forecasting system of hydrometeorological hazards across scales through the use of advanced sensing technology and an innovatively coupled modeling framework. This vision synergizes with the decision-making process under uncertainty (presentation by K. Nishijima). In the risk perspective, social sciences provide essential contributions to Earth science challenges. The communication of weather-related risk information has important implications for the general public's perception of risk, which influences their response to disasters, as highlighted in a talk by H. Jenkins-Smith (National Institute for Risk and Resilience, OU).

UNDERSTANDING AND PREDICTING HIGH-IMPACT WEATHER AND CLIMATE EXTREMES. The summit had 31 presentations in three sessions on this topic. In line with the Norman Weather Enterprise and KU expertise, the predictability of natural hazards was a major emphasis of the symposium. The ultimate goal is to mitigate the risk associated with the detrimental impacts and potential costs that weather and climate extremes pose on society and economic activities, specifically in the context of changing climate and growing urbanization (K. Yamaguchi). To provide accurate predictions of weather- and climate-related threats, such as storms, floods, winter ice/snow storms, droughts, heat waves, and climate extremes, there is a need for data collection and analysis over a range of scales up to the climate scale through novel observations enabled by emerging technologies and the state-of-the-art computational resources and forecast models (Stensrud et al. 2009). Climate change in the polar regions is a driver for enhanced prediction capability over lower latitudes (Jung et al. 2015), as discussed by the Arctic and Antarctic Atmospheric Research Group at OU. Other large-scale processes, such as the stratosphere–troposphere coupling in the tropical region, were shown to influence extreme weather (S. Yoden). Several presentations highlighted data assimilation and ensemble prediction techniques to advance the skill of prediction at global, regional, and convective scales (keynote talks by M. Xue and X. Wang). These techniques face a number of challenges, such as dealing with interactions across several scales, model structural limitations and errors in representation of physical processes (e.g., land–atmosphere interactions and boundary layer), indirect information provided by remote sensing observations (e.g., radial velocity from airborne radars, satellite radiances), and the complex interactions between storm dynamics and microphysics. Another theme was on urban hazards, such as heavy precipitation and flash floods, which call for very-high-resolution observations and numerical model simulations of convection genesis. Three presentations focused on hydrometeorological hazards induced by severe weather such as flash floods over the United States (J. J. Gourley) and Pakistan (T. Sayama) and highlighted the combination of meteorological, hydrological, and societal factors.

ADVANCES IN THE REMOTE SENSING OF THE ATMOSPHERE. The summit had 14 presentations in two sessions on the pivotal topic of emerging technologies to address Earth challenges characterized by multiscale and fast-evolving phenomena. The focus was on the design and application of innovative remote sensing technology such as advances in radar (Bluestein et al. 2014) and satellite observations. Five papers focused on the next generation of radar systems developed in Norman through the Multifunction Phased Array Radar (MPAR) program. This program aims to provide improved temporal resolution and operational flexibility to concurrently perform aircraft and weather surveillance (C. Fulton). New radar systems allow capturing rapidly evolving hazardous weather events, such as the experimental X-band atmospheric imaging radar (AIR). Other projects highlight collaboration between OU and KU using large-eddy model simulations to understand tornado debris signatures observed by dual-polarization radar and how debris affect tornado dynamics (D. Bodine and T. Maruyama). Recent advances in airborne radar signal processing enhance the retrieval of vertical wind velocities (T. Hashimoto). Several presentations discussed the development of new techniques on polarimetric radar for boundary layer clear-air sensing, hydrometeor classification, and drop size distribution retrievals (keynote talk by A. Adachi). They highlight the synergy between research and operation through analysis of operational radar data from the U.S. operational radar network (A. Ryzhkov). Quantitative precipitation estimations from satellite over the United States, China, and Africa were addressed in four presentations (keynote talk by H. Ishikawa). In the context of Japan Aerospace Exploration Agency (JAXA)/National Aeronautics and Space Administration (NASA) Global Precipitation Measurement mission (Hou et al. 2014), they stress the major advantage of the vantage point from space to monitor precipitation at the global scale compared to sparse ground-based observations offered by rain gauge and radar.

MITIGATION OF EXTREME WEATHER AND CLIMATE VARIABILITY IMPACTS. The summit had five presentations in one session on this topic, highlighting the expertise of Kyoto University in the perception of risk, which influences the human response to disasters. The risk of potential damages caused by typhoons in the context of current and warming climate was assessed though a hazards ensemble simulation approach (H. Ishikawa). How to improve the forecasts of precipitation and floods in complex terrain at shorter lead times (W. Yu) was discussed. In the context of an occurring hazard event, risk reduction actions are shown to depend on the dynamics of impacts and the availability of forecasts of the evolution of the natural hazard (K. Nishijima). The risk decision-making process can be formalized to optimize the risk reduction actions in real time by accounting for the available information and related uncertainty with probabilistic models.

EARTH-SCIENCE CHALLENGES AND BEYOND. The summit had 11 presentations in one session on this topic. The talks addressed science questions that motivate research programs in both universities. One theme was on extreme convective weather, specifically tornadic storms in both Japan and the United States with an emphasis on urban areas. Furthering our understanding through theory, modeling, and observation (rapid-update radar and satellite) was stressed to ultimately improve forecasting and mitigation (E. Nakakita). Winter precipitation was also identified as a major challenge, since reliable snow water equivalent and depth estimates from observations (gauge, radar, or satellite) are limited while such measurements represent a major contribution to water resources. Another theme was global hydrology and the need for uncertainty information in hydrological prediction (Beven 2010). Since precipitation is the primary driver of the timing and stage of river discharge, needs for higher accuracy and resolution of quantitative precipitation estimation and forecasts were stressed to benefit the hydrologic community (Y. Hong). More generally, our understanding of the interactions between climate and the water cycle should be advanced in order to address water resources and their management. An evaluation of the uncertainties in model projections is essential to address the impact of climate variability on hydrological processes and extreme hydrological events, specifically in sparse data regions. Integration between atmospheric and hydrologic observation and modeling using ensemble approaches and data assimilation techniques would provide more consistent inputs for the risk decision process. Other presentations in this topic highlighted the role of carbon cycle in climate projections and terrestrial ecosystems, as well as the growing use of unmanned aerial systems for atmospheric research (P. Chilson).

CONCLUSIONS. The fifth ISEC symposium will be held in 2017 in Kyoto. Since 2009 the ISEC symposia have fostered greater collaboration between both universities, primarily through faculty sabbaticals and extended stays for students, and have led to new joint projects (e.g., on tornados debris flows) and a deeper collaboration. During ISEC 2015, the Japan Society for the Promotion of Science (JSPS) Washington Office presented funding programs for international collaborations and fellowships that could accelerate cooperative research and education activities between Kyoto University and the University of Oklahoma. Future symposia will broaden the relationship by including more institutes and areas of research building upon the original OU–KU nexus of radar technology, remote sensing, modeling data assimilation, and disaster prevention.

REFERENCES

Beven, K., 2010: *Environmental Modelling: An Uncertain Future?* CRC Press, 328 pp.

Bluestein, H. B., and Coauthors, 2014: Radar in atmospheric sciences and related research: Current systems, emerging technology, and future needs. *Bull. Amer. Meteor. Soc.*, **95**, 1850–1861, doi:10.1175/BAMS-D-13-00079.1.

Hou, A., and Coauthors, 2014: The Global Precipitation Measurement Mission. *Bull. Amer. Meteor. Soc.*, **95**, 701–722, doi:10.1175/BAMS-D-13-00164.1.

Jung, T., and Coauthors, 2015: World Meteorological Organization WWRP Polar Prediction Project report. WWRP-PPP-SG6 Final Rep., 18 pp. [Available online at www.polarprediction.net/fileadmin/user_upload/redakteur/Home/Steering_Group/Meetings/SG-6/PPPSG6_REPORT_27082015.pdf.]

Lewis, J., and S. Lakshmivarahan, 2008: Sasaki's pivotal contribution: Calculus of variations applied to weather map analysis. *Mon. Wea. Rev.*, **136**, 3553–3567, doi:10.1175/2008MWR2400.1.

Rothfusz, L., C. D. Karstens, and D. Hilderbrand, 2014: Forecasting a continuum of environmental threats: Exploring next-generation forecasting of high impact weather. *Eos, Trans. Amer. Geophys. Union*, **95**, 325–326, doi:10.1002/2014EO360001.

Stensrud, D. J., and Coauthors, 2009: Convective-scale warn-on-forecast system: A vision for 2020. *Bull. Amer. Meteor. Soc.*, **90**, 1487–1499, doi:10.1175/2009BAMS2795.1.