MITIGATING THE IMPACT OF SEVERE WEATHER AND CLIMATE VARIABILITY THROUGH INNOVATIVE SENSING, MODELING, AND PREDICTION

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The International Symposium on Earth-Science Challenges (ISEC) 2013 is the third summit to highlight the partnership between the University of Oklahoma (OU) and Kyoto University (KU) of Japan. More than 100 participants attended the summit, with graduate students making up about a third of the attendees. The summits began in 2009 to share recent advances in the research and education of Earth sciences. These biannual symposia are held alternately between Kyoto, Japan, and Norman, Oklahoma (see the sidebar for the history between the universities). The ISEC 2013 focused on promoting interdisciplinary education and research to understand, forecast, and mitigate natural disasters, including high-impact weather and climate variability, through innovations in sensing, modeling, and prediction sciences and technologies.

INTERNATIONAL SYMPOSIUM ON EARTH-SCIENCE CHALLENGES (ISEC) 2013

What: More than 100 scientists, engineers, and students met to address the challenges in climate variability and extreme weather through observations with innovative sensors and sensor technology as well as numerical modeling, assimilations, and prediction with the goal of building a resilient society.
When: 3–5 October 2013
Where: Kyoto, Japan

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UNDERSTANDING AND PREDICTING HIGH-IMPACT WEATHER. The summit had 18 presentations in three sessions on this topic. Several themes were evident in these sessions. One theme was the need and utility of next-generation weather radars with far more rapid update time, polarimetric capability, and the ability to sample weather in the presence of significant orography. Weather phenomena addressed with these systems included tornadic storms in both countries and downslope winds in Japan. It was clear that these advanced systems were furthering our understanding of the dynamics of high-impact weather. Other

observational strategies included integrated boundary layer measurements and videosonde technology. Another broad theme was a focus on a variety of state-of-the-art modeling approaches, including realistic computational fluid dynamic simulations with horizontal grids of ~50 m. Advances in computational capabilities allowed these high-resolution sensors to cover a broader area. The combination of these high-resolution simulations with the new radar capability represents a growing trend in the atmospheric sciences. Additional papers discussed the development and testing of microphysical schemes, nowcasting systems, high-resolution simulations in complex terrain, and ensemble-based data assimilation and prediction systems. The scales of interest ranged from tornadoes and terrain-induced circulations to global modeling. The session was a testament to the growth in recent years in ensemble data assimilation research across the international academic community.

HISTORY OF COLLABORATION BETWEEN THE UNIVERSITY OF OKLAHOMA AND KYOTO UNIVERSITY

Naoto Oshiman, director of the Disaster Prevention Research Institute (DPRI) at KU, and Toshitaka Tsuda, director of RISH at KU, began the ISEC 2013 with welcoming addresses. These warm welcomes were followed by the opening special talk by Yoshi Sasaki (OU) on entropic balance theory and variational field Lagrangian formalism. Sasaki's scientific accomplishments span a remarkable seven decades, which began with the noteworthy scientific contribution of the first numerical prediction of typhoon tracks (Sasaki and Miyakoda 1955). Upon joining OU in 1960, Sasaki continued his research, including efforts in numerical modeling and the development of variational techniques for objective analysis. His early effort formed the foundation of variational modern-day data assimilation systems, which are essential for numerical weather prediction (e.g., Lewis and Lakshmivarahan 2008).

The collaboration between the two programs can be traced to the 1950s when Sasaki met Michio Okamoto on their journey from Yokohama, Japan, to the United States. Okamoto subsequently became Kyoto University's 19th president in 1973, and Sasaki was instrumental in the founding of the meteorology program at OU. The first official agreement between the two universities was signed in 1991, focusing on academic exchanges and on research leading to natural disaster prevention and mitigation and was renewed in 2008. The spirit of collaboration extends beyond the universities, as Sasaki also played a leading role in the formation of the sister state/prefecture relationship between Oklahoma and Kyoto in 1985.

ADVANCED REMOTE SENSING DEVELOPMENT AND OBSERVATION. The summit had 19 presentations in three sessions on this topic with the focus on the design, development, application, and assessment of innovative remote sensing technology. For weather radar, the advantages of phased array radars with solid-state amplifiers and pulse compression techniques were clearly evident. These radar systems allow, for the first time, the ability to adequately capture rapidly evolving hazardous weather events through ultra-high temporal resolution (~10 s or less) and extremely flexible scanning. This breakthrough is accomplished through electronic beam steering based on digital beamforming techniques. Papers related to the development of two X-band systems were presented: the atmospheric imaging radar (AIR) designed and built by the Advanced Radar Research Center (ARRC) at OU (Isom et al. 2013) and the phased array weather radar (PAWR) developed by Toshiba Corporation and Osaka University in Japan (Ushio et al. 2013).

Several presentations discussed the application of polarimetric radar and the development of new techniques related to improving microphysical retrieval, quantitative precipitation estimation, and microphysical parameterization in numerical models. This session also illustrated the unique opportunities to enhance the collaboration between the research and operational communities through analysis of data made available through the recent dual-polarization upgrade to the U.S. operational Doppler radar network. Presentations also illustrated new applications of polarimetric radar, such as quantitative volcanic ash estimation, boundary layer clear-air sensing, and radar aeroecology.

Radar wind profilers can provide continuous monitoring of atmospheric condition such as 3D wind, virtual temperature, and turbulence. A novel system using an active phased array Luneberg lens antenna was developed at the Research Institute for Sustainable Humansphere (RISH), where multiple frequencies and range oversampling were implemented simultaneously to improve the range resolution. Several new techniques for profiling were presented, including measuring the near-surface humidity field from the sidelobes, an integrated sensor approach to estimate trace gases, and the use of a compact multispectral detector for rotational Raman lidar in order to improve the accuracy of temperature profiling. For satellite-based sensing, the focus was

on applications of Japan's dense network of ground-based receivers to estimate precipitable water vapor measurements from the Global Navigation Satellite System.

EXTREME WEATHER AND CLIMATE VARIABILITY FOR MITIGATION. The summit had six talks in this session that spanned a variety of topics. For climate variability, the talks included studies aimed at understanding and predicting the regional impacts of climate change and variation, as the regional influences are where many of the societal, economic, and environmental changes are felt. These talks included statistical downscale (S. Kim), and three talks focused on the Arctic (S. M. Cavallo, D. Lusk, and N. Szapiro). Aspects of the Arctic talks focused on coupling atmospheric processes with sea ice. Another presentation (J. Ninomiya) dealt with the coupled modeling aspects of waves, ocean currents, and typhoons. The final presentation was exploring the sensitivity of forecasts over Europe to convection over central North America (S. Lillo) utilizing the European Centre for Medium-Range Weather Forecasts (ECMWF) system. The work was a follow on to a study by Rodwell et al. (2013), who showed the largest errors in European forecasts were associated with upstream convection over this region. The presentations by Lillo and Szapiro show the need for new modeling systems, such as the Model for Prediction Across Scales (MPAS) (Skamarock et al. 2012), that can directly resolve convection and greater aspects of orography and land–sea processes locally within a global model.

SPECIAL SESSION ON EARTH-SCIENCE CHALLENGES AND BEYOND. This session concentrated primarily on major projects and programs of the two universities. For KU, these programs included a presentation by H. Ishikawa on the Global Centers of Excellence (GCE)'s focus on sustainability, survivability, and resilient societies for extreme weather conditions. Through interdisciplinary efforts that span physical science, engineering, and social science, GCE provides opportunities for graduate students, postdoctoral fellows, and early career faculty. Overseas components exist in Bangladesh, India, Niger, and Ghana. The focus of such interdisciplinary expertise on education and international outreach was noted as impressive by many of the U.S. participants. Other Japanese programs included a long-term project focused on sudden stratospheric warmings (S. Yoden), building adaptation strategies against climate change (E. Nakakita), and studying gravity wave observations through the unique and impressive middle and upper atmosphere (MU) radar and GPS radio occultation systems (T. Tsuda).

The OU presentations began with one by R. Palmer on the research growth of the University of Oklahoma, which led to a "very high" research designation in the Carnegie Classification of Institutions of Higher Education framework and a recent award for the 2013 outstanding research park in the nation. This growth was accomplished through a focus on weather, radar, water, and climate. Other talks focused on activities at OU, including the large errors in treating nocturnal convection of the U.S. Great Plains as the motivation for the upcoming interagency Plains Elevated Convection at Night (PECAN) project (D. Parsons), the progress in high-resolution data assimilation and modeling at the Center for Analysis and Prediction of Storms (CAPS; M. Xue), and the challenges and innovations in radar development and application at the Advanced Radar Research Center (AARC; T.-Y. Yu).

CONCLUSIONS. In addition to the oral sessions described here, the summit had 21 poster papers covering a broad range of topics related to the previously discussed sessions and the broad goals of the summit. The decision of the steering committee was to continue this series with the next summit hosted by OU. To date, these meetings have fostered greater collaboration between these universities, but primarily on a principal investigator–to–principal investigator basis with support from grants that support international exchanges, such as from the National Science Foundation (NSF). In order to further the benefits of this collaboration, the steering committee has encouraged the teaching of short courses on special topics at the future summits as a means of broadening the student experience through exposing them to topics not taught at their own universities. The personal benefit of this experience for many U.S. (Japanese) students was noted, as it was the first time many had traveled to Asia (the United States).

REFERENCES

Isom, B., and Coauthors, 2013: The atmospheric imaging radar: Simultaneous volumetric observations using a phased array weather radar. *J. Atmos. Oceanic Technol.,* **30,** 655–674, doi:10.1175/JTECH-D-12-00063.1.

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.

Rodwell, M. J., and Coauthors, 2013: Characteristics of occasional poor medium-range weather forecasts for Europe. *Bull. Amer. Meteor. Soc.,* **94,** 1393–1405, doi:10.1175/BAMS-D-12-00099.1.

Sasaki, Y., and K. Miyakoda, 1955: Prediction of typhoon tracks on the basis of numerical weather forecasting method. *Proc. UNESCO Symp. on Typhoons,* Tokyo, Japan, Japanese National Commission for UNESCO, 221–234.

Skamarock, W. C., J. B. Klemp, M. G. Duda, L. D. Fowler, S.-H. Park, and T. D. Ringler, 2012: A multiscale nonhydrostatic atmospheric model using centroidal Voronoi tesselations and C-grid staggering. *Mon. Wea. Rev.,* **140,** 3090–3105, doi:10.1175/MWR-D-11-00215.1.

Ushio, T., and Coauthors, 2013: Observation and initial comparison of the phased array radar at X band. *36th Conf. on Radar Meteorology,* Breckenridge, CO, Amer. Meteor. Soc., 4B.3. [Available online at https://ams.confex.com/ams/36Radar/webprogram/Paper228470.html.]