The Republic of Korea-Pacific Islands Climate Prediction Services Project

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Seasonal prediction provides critical information for the tropical Pacific region, where the economy and livelihood of the population are highly dependent on climate variability. The usage of seasonal prediction for short-term climate variability is also a no-regret measure to adapt to climate change, one of the biggest threats in this region. Recent progress in dynamical seasonal prediction has improved the quality of climate services of many National Meteorological and Hydrological Services (NMHSs) around the world. While the highest skills of dynamical prediction systems are usually found in the tropical Pacific, NMHSs in the tropical Pacific do not have the necessary access or means to transform this high-quality scientific information into a decision-making tool. Current seasonal prediction in the tropical Pacific region relies heavily on the empirical relationship between the regional climate and El Niño–Southern Oscillation (ENSO) (Charles et al. 2011). While ENSO is the largest source of predictability, the variety of its local impacts and its changing characteristics limits the skill of the empirical forecasting system.

The gap between regional ENSO information, local place-based forecasts, and management information was recognized by the Pacific Islands Meteorological Strategy (PIMS) through the Majuro Declaration for Climate Leadership, as well as by the Republic of Korea (ROK) during the Asia-Pacific Economic Cooperation (APEC) Leader's Summit in 2013. The Republic of Korea-Pacific Islands Climate Prediction Services (ROK-PI CliPS) project was initiated accordingly as a multiyear project in 2014. ROK-PI CliPS aims to provide high-quality climate data and value-added climate information through development of a regionally tailored seasonal climate prediction system, and to promote the building of NMHS capacity for climate prediction services in order to contribute to community resilience and national development planning. It is funded by the Ministry of Foreign Affairs (MOFA), Republic of Korea, through the ROK-Pacific Islands Forum (PIF) Cooperation Fund (RPCF), which is managed by the Pacific Islands Forum Secretariat (PIFS). It is jointly implemented by the APEC Climate Center (APCC) and Secretariat of the Pacific Regional Environmental Programme (SPREP).

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SCOPE AND STRATEGY. The overall objective of ROK-PI CliPS is to strengthen the adaptive capacity of vulnerable communities in the Pacific region to climate risks at the seasonal time scale by building a regional mechanism to produce locally tailored seasonal climate information in the Pacific Island countries (PICs). The scope of ROK-PI CliPS (see Fig. 1) is accomplished through the following four pillars discussed in the subsections below (also indicated on the left side of Fig. 1). The detailed strategies associated with the pillars (in yellow in the middle of Fig. 1) are designed to generate the final outcomes (presented on the right of Fig. 1) through achieving the gradational goals (at the bottom of Fig. 1). The expected outcomes include establishing a regional prediction system to collect and provide multimodel-based dynamical seasonal forecasts and developing a tailoring methodology and tool for each country. It also includes capacity building of NMHS in PICs for sustainable operation of the resulting seasonal prediction system.

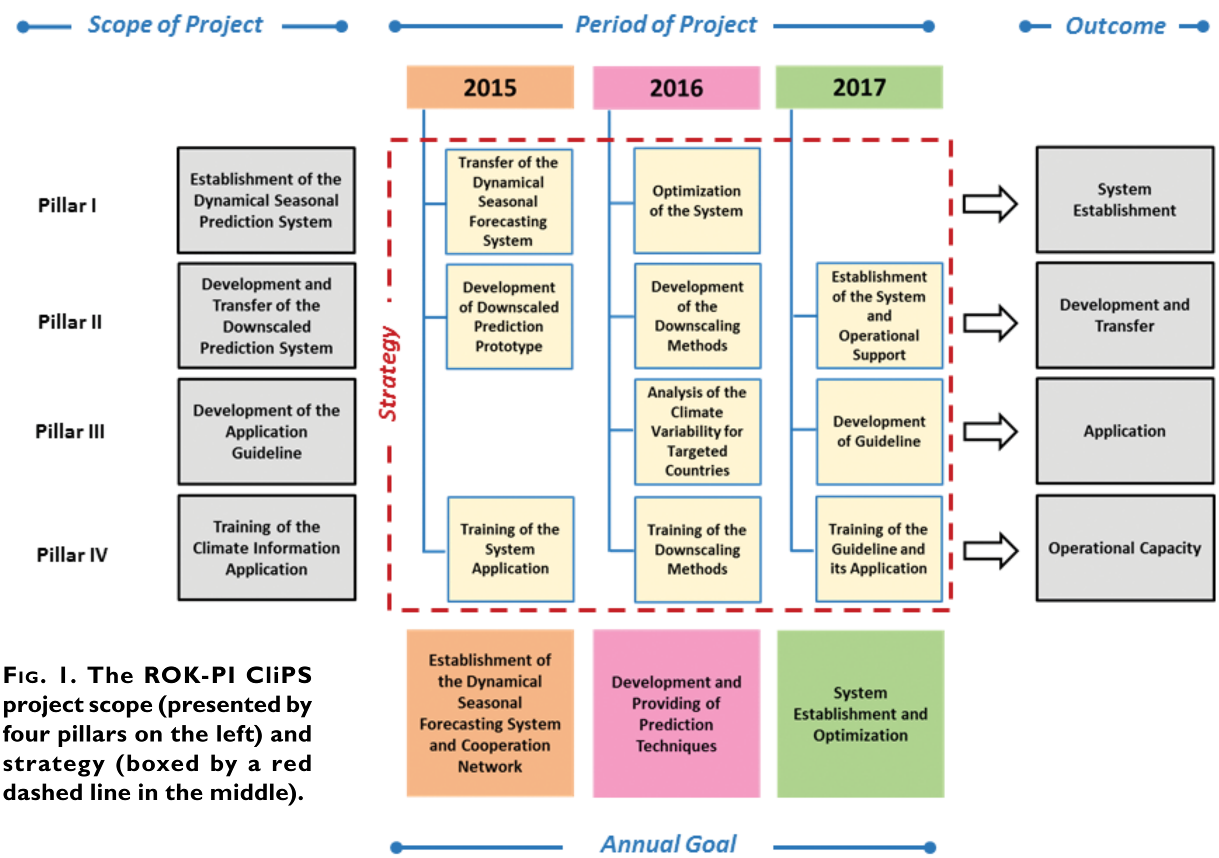

Fig. 1. The ROK-PI CliPS project scope (presented by four pillars on the left) and strategy (boxed by a red dashed line in the middle).

Establishment of the dynamical seasonal forecasting system. Current seasonal prediction in the PICs relies upon a few empirical climate drivers (e.g., ENSO) due to the limited resources and capacity for dynamical seasonal prediction. When the empirical association between the local climate and the main drivers is neither clear nor robust, the climate prediction is also limited. Figure 2, however, suggests that seasonal prediction can further benefit from dynamical seasonal predictions. Figure 2 provides the correlation maps of the sea surface temperature (SST) onto the observed rainfall variability at Apia, Samoa (station 91762; marked as a closed circle in red), based on observations (Fig. 2a) and model simulations (Fig. 2b), for the June–August (JJA) seasons during the years 1983–2005. The observed SST pattern associated with rainfall variability in Apia (see Fig. 2a) indicates that there is large-scale non-ENSO climate variability associated with local climate fluctuation. For instance, the impacts of SST changes in the southwestern Pacific on local-scale rainfall variability exist. It can also be predicted by the model to some extent (shown in Fig. 2b) and utilized as a predictor in downscaling to predict the local climate.

ROK-PI CliPS targets the subscribers (i.e., forecasters, users, and communities) in the PICs to access the detailed dynamical seasonal forecast information. Thus, a key activity of this pillar is to establish a reliable dynamical seasonal forecast system for the PICs. First, APCC disseminates a zoomed-in operational 6-month multimodel ensemble (MME) Climate Outlook for the Pacific Island Countries (CO-PICs) on a monthly basis. Unlike global outlooks, the CO-PICs shows the regional details of the probabilistic forecast and verification information over the PIC region. For example, Fig. 3 shows the probabilistic MME seasonal precipitation forecast for the October–December (OND) 2016 period. It is issued in the form of tercile-based categorical probabilities—that is, the probability of below-normal, near-normal, and above-normal categories, with respect to climatology. Second, a dynamical seasonal forecast system, Climate Information Toolkit for the Pacific [CLIK℗; (e.g., Fig. 4, http://clikp.sprep.org)], is established in SPREP, Samoa. CLIK℗ is an online tool that guides climate forecasters and decision makers by providing them with the means to create their own MME forecast and allowing them to experiment with

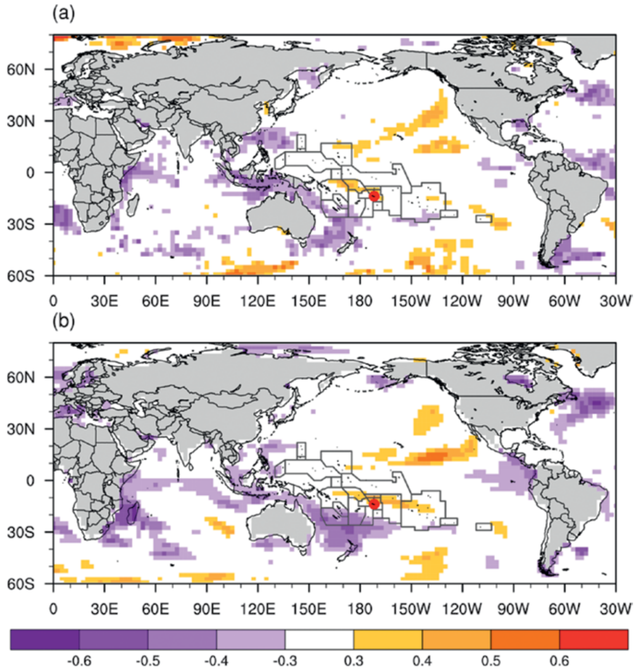

Fig. 2. Correlation maps of the sea surface temperature (SST) onto the observed rainfall variability at Apia, Samoa (station 91762; marked as a closed circle in red), based on (a) observations and (b) model simulations, for the JJA seasons during the years 1983–2005.

various combinations of multimodels to find the best consensus forecast based on the prediction skill of the targeted region of interest. In practice, MME provides a better means for correcting for systematic biases in model performance in the tropical Pacific, where the potential predictability (i.e., signal-to-noise ratio) is quite high. Therefore, the tool makes the users consider the climate model's performance more and leads them to build up their knowledge and experience. CLIK℗ will serve to improve the way climate forecasts are generated in developing island countries in the Pacific that lack modern climate prediction systems. It will also play the role of a regional hub to collect and provide dynamical seasonal prediction data in the region.

Development and transfer of the downscaled prediction system. The second pillar is a key factor of ROK-PI CliPS, which aims to bridge the gap between the general circulation model (GCM) outputs and station-based local climate. Current regional capacities for station-scale climate prediction using GCMs are limited. Figure 5 shows the resolution of GCMs and their prediction skill for the local climate. The three stations considered, Afiamalu, Faleolo, and Apia, are geographically close to each other (with a distance of around 10–30 km from each other) and have different topographical features. The rainfall gauges for the stations are placed in mountains, an airport, and a coastal area, respectively. Based on the GCM-based predictions taken from one grid point (in common for the local climate predictions at the three different stations), MME cannot properly predict local rainfall variability for each station, and the predictability varies especially from one station to another (shown in Fig. 5b). However, at the same time, this represents an opportunity to improve locally tailored seasonal prediction. Given the limitations of coarse-resolution GCMs and the locality of targeted stations, ROK-PI CliPS seeks to develop and establish a hybrid dynamical–statistical climate prediction system using region-specific downscaling methodologies. Local precipitation data are collected from 49 stations in 13 island countries, including Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Republic of Marshall Islands, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga,

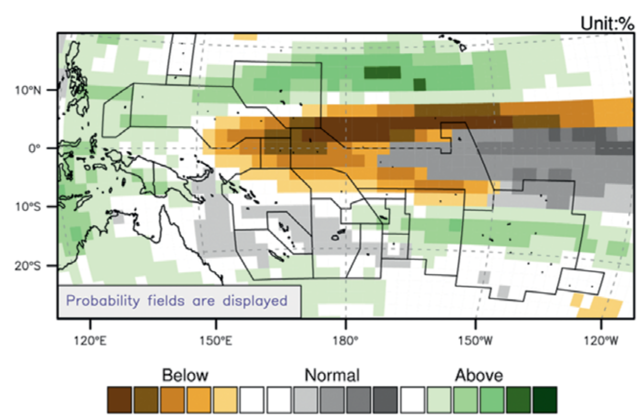

Fig. 3. APCC probabilistic MME seasonal forecast map for the tropical Pacific precipitation for Oct–Dec 2016. Shown is the combined probability map of the above-normal, near-normal, and below-normal categories, with the regions where the dominant forecast category is statistically certain. Strongly enhanced probability for below-normal precipitation is predicted for southeastern Micronesia and equatorial Polynesia. Over equatorial Polynesia, the most probable precipitation category is near normal. Enhanced probability for above-normal rainfall is predicted for northern Polynesia, most of Micronesia, and western Melanesia.

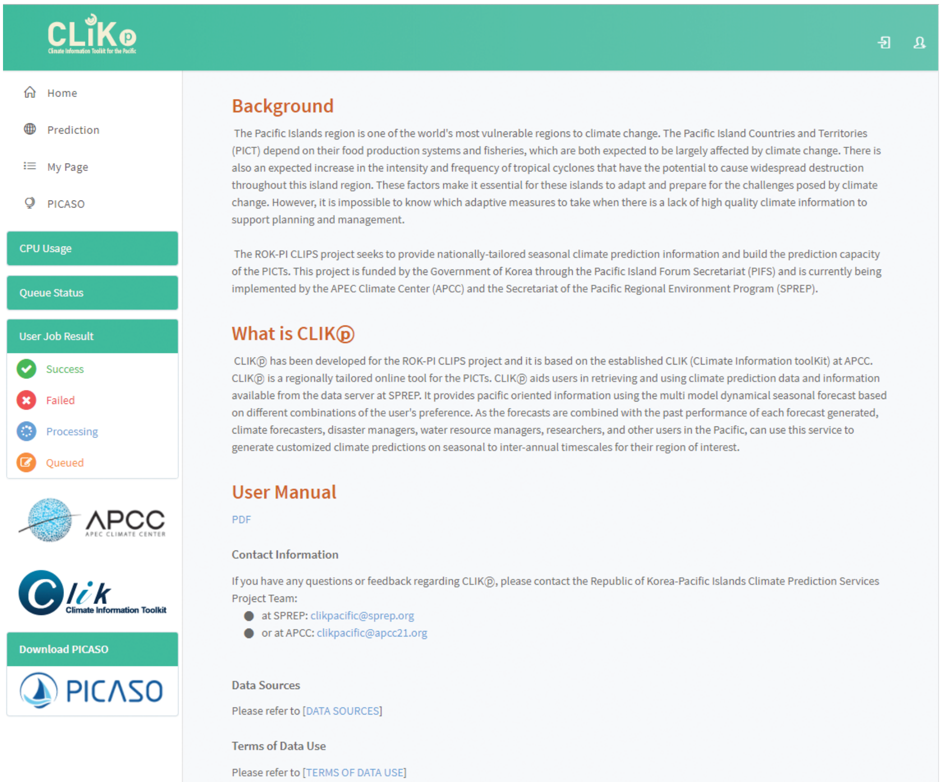

Fig. 4. The CLIK℗ main page. CLIK℗ is a regionally tailored online tool for the Pacific Island countries and territories that aids users in retrieving and using climate prediction data and information.

Tuvalu, and Vanuatu. The downscaling system is built upon identifying the predictable physical relationship between the local precipitation variability and large-scale circulation. The main downscaling system will be installed and operated in the CLIK℗ server at SPREP, whereas the visualization tool [Pacific Island Countries Advanced Seasonal Outlook (PICASO)] is provided to each NMHS to utilize the output for their operational activities.

Development of the application guidelines. For this pillar, APCC and SPREP will develop an application guideline for NMHSs to effectively manage the climate information produced by the system and publish climate prediction information for application to decision-making processes. The guidelines are designed to achieve a better understanding of major climate drivers that have potential impacts on local climate variability and their reproducibility in the climate models. Also, the application guideline will provide additional information to assist NMHSs to interpret the tailored climate predictions, such as the variation of prediction skills as well as the explanation of predictors used in the downscaling methodology. It will help NMHSs to make full use of the large-scale and locally tailored information.

Training for application of climate information. APCC and SPREP held annual training workshops following the progress of the project. Initially, trainings on the current dynamical seasonal prediction as well as on the CLIK℗ system established at SPREP were conducted to enhance climate officers' understanding and accessibility to the climate model outputs. During the second training in 2016, which had a basic concept of tailoring and downscaling dynamical seasonal prediction, APCC staffs and climate officers from NMHSs jointly identified potential predictors for the downscaling prediction system. In addition, APCC extended the Young Scientist Support Program (YSSP) to the Pacific region, a short-term visiting scientist program at APCC, to strengthen the capacities in climate prediction science and set a cooperation network for future joint research (see www.apcc21.org for details). Subsequent training programs were held on the application guidelines to increase the operational utility of the products. A total of 114 Pacific Island climate officers were trained (39% female climate officers) through this project.

LESSONS LEARNED AND SUSTAINABLE CAPACITY BUILDING. ROK-PI CliPS strives to enhance the capacity of the national climate services in PICs by building a regional mechanism to produce localized hybrid dynamical–statistical seasonal prediction. A series of trainings, application guideline development, and participatory development activities were conducted to ensure the sustainability of the mechanism.

However, the remoteness of the Pacific Islands and the insufficient resources of each NMHS create a challenging situation for improving climate prediction services, which require a large amount of climate data and timely delivery of information produced by modern technologies. To overcome this limitation, ROK-PI CliPS developed a strategy to split the computation server and the visualization tool to be housed at SPREP and at NMHSs, respectively. Through this, the amount of information that needs to be transferred can be minimized, and the transferred information can be easily tailored to meet the various needs of national stakeholders.

This strategy may be expanded into an institutionalized arrangement for more effective and sustainable climate prediction services in the region. Developing a regional entity dedicated to support climate science and technology required for national climate services and operations should be considered. Considering the high potential predictability, the Pacific Islands is the most promising region (Kang et al. 2004) where climate prediction can lead to tangible socioeconomic benefits. ROK-PI CliPS attempts this regional mechanism in a limited scope, and it is scheduled to end in December 2017. Successive efforts to sustain and further improve climate predictions in the Pacific Islands region are required.

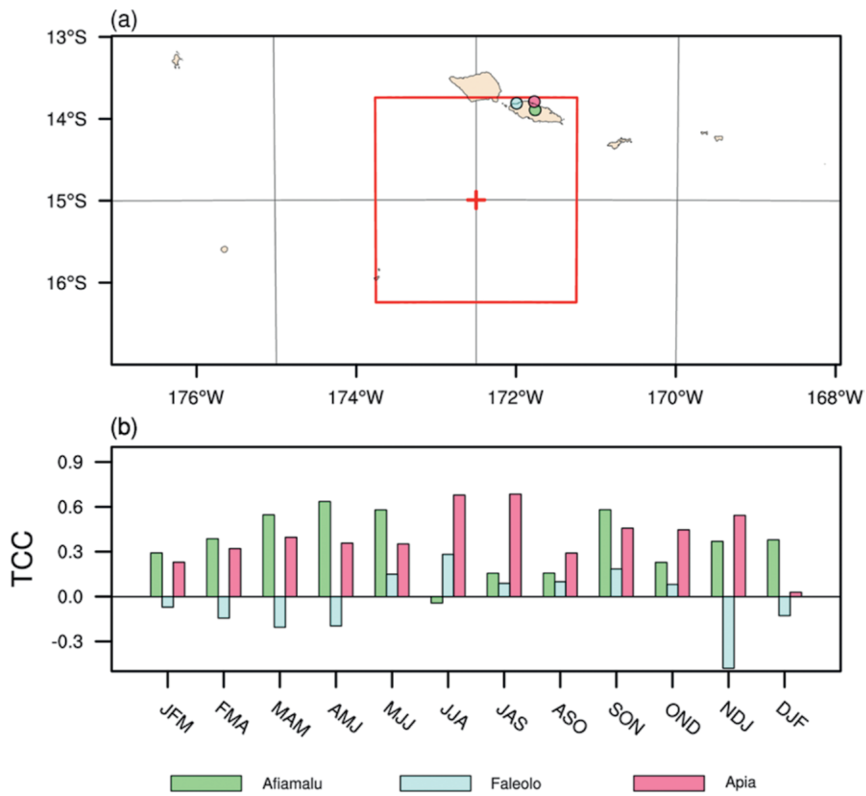

Fig. 5. (a) The surrounding area (2.5° by 2.5° grid mesh) of Samoa and the locations of the three targeted stations: Afiamalu (marked as a closed circle in green), Faleolo (light blue), and Apia (pink). The representative value in the red rectangle (marked by a red cross) from model simulations is used as the common base for generating local climate predictions at the three different stations. (b) Temporal correlation coefficient (TCC) between observed and MME-simulated seasonal-mean precipitation for the three stations.

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FOR FURTHER READING

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