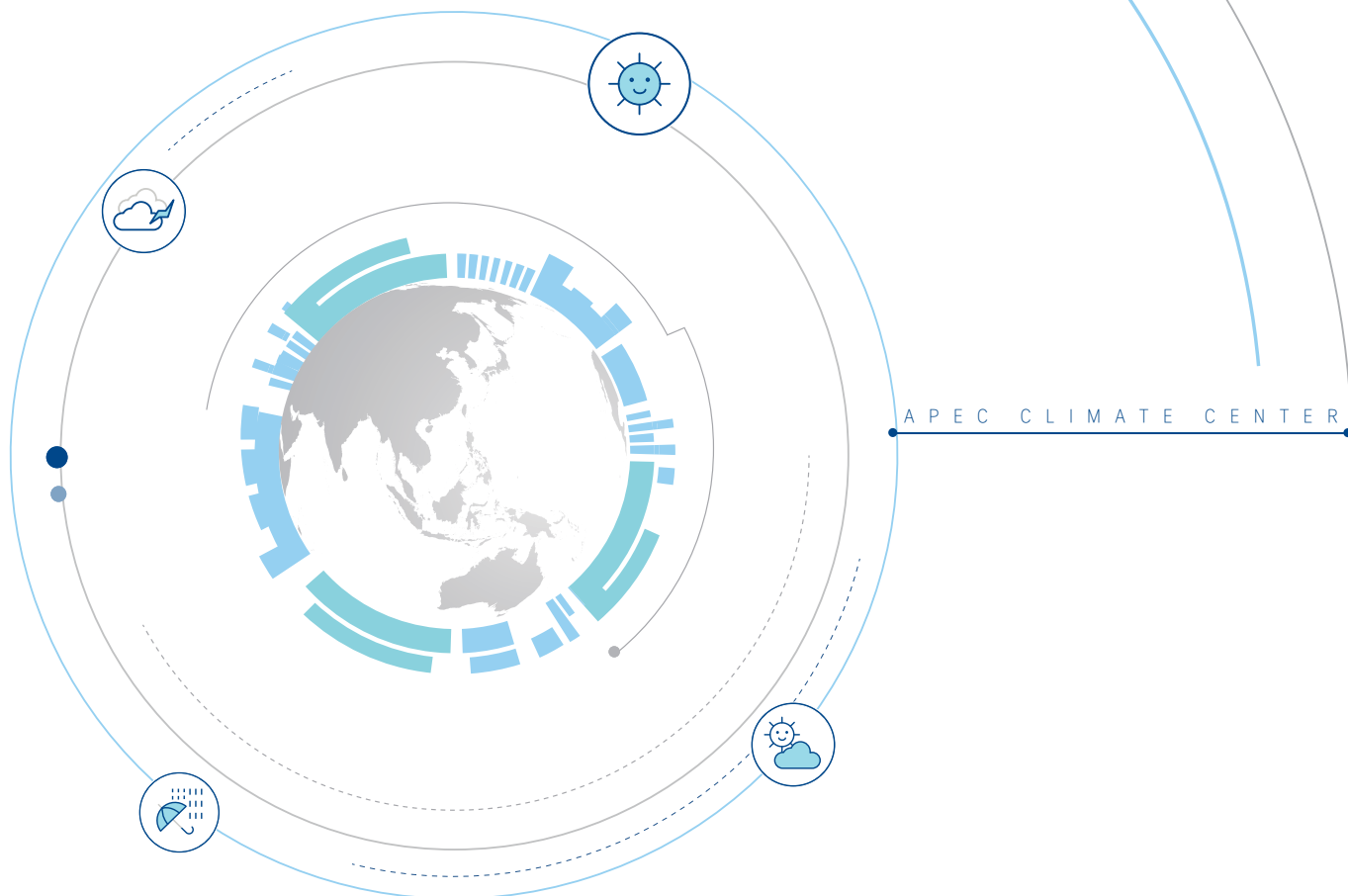




APEC CLIMATE CENTER
2024 Annual Report

APEC CLIMATE CENTER
2024 Annual Report



Foreword



Producing and utilizing more reliable climate and climate change monitoring and forecasting information has become increasingly important to cope with climate disasters caused by the abnormal weather conditions that are currently occurring more frequently worldwide.

Under these circumstances, the Act on the Monitoring and Forecast of Climate and Climate Change, which aims to strengthen the legal foundation for establishing a national climate change response system and specify the production and sharing of information on climate change monitoring and various climate forecasts, came into effect on October 25, 2024, further strengthening the climate crisis response system.

The Act has also enabled the APCC to clarify its identity and devote itself to domestic and international cooperation in order to promote the development of climate and climate change monitoring and prediction technologies and the utilization of related climate information in the Asia-Pacific region.

The APCC has engaged in constructing a climate network among APEC member economies (hereinafter referred to as member economies), produced and shared optimal climate prediction information, and been continuously exploring how to jointly handle extreme climate in the member economies, including the Republic of Korea. It has also contributed to strengthening domestic and international climate crisis response capabilities by developing core climate prediction technologies, APCC's core task, and showing research and project achievements.

Meanwhile, the APCC was rated as "Excellent" by the "Asia-Pacific Climate Information Service and R&D Project," which was conducted from 2022 to 2024. Its climate research and project capabilities have been recognized by government agencies, including the Korea Meteorological Administration(KMA); leading climate-related organizations; and academia. The project contributed to an innovative improvement of climate prediction performance and to the strengthening of the monitoring and prediction system for extreme climate in the Republic of Korea and the Asia-Pacific region.

Furthermore, in July 2024, the APCC established a cooperation system with 16 organizations in the Haeundae Centum District in Busan to enhance sustainable ESG (environmental, social, and governance) management activities and promote community coexistence and development. As a public institution, the APCC has contributed to the public interest and development of the local community through its specialized strengths: socially responsible management and social contribution activities.

The APCC has strived to become a global climate and climate change monitoring and prediction hub that can lead the response to the climate crisis in the Asia-Pacific region and the world. Simultaneously, the APCC will continuously evolve from its initial required role and respond to the changing demand for domestic and international climate crisis responses.

To this end, the APCC will further develop its core technologies for climate and climate change monitoring and prediction and strengthen cooperation in the field of climate and climate change not only with the international community but also with government agencies, including the KMA, and related organizations in the Republic of Korea.

I would like to express my deepest gratitude to the APCC staff for their tireless efforts and to the KMA and partner organizations for their support in helping the APCC achieve valuable outcomes in 2024.

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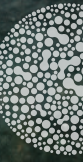
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APEC Climate Center





Extreme Climate in the Asia-Pacific Region in 2024



Extreme Climate in the Asia-Pacific Region in 2024

01 Extreme Climate in the Asia-Pacific Region in 2024

The World Meteorological Organization (WMO) revealed that the global average temperature in 2024 increased by 1.55 °C from the pre-industrial (1850–1900) period. The highest global average temperature since Industrialization was recorded in 2024. It was the first year in which the global average temperature was more than 1.5 °C higher than in the past, meaning that the threshold set by world leaders at the 2015 Paris Agreement/Conference of the Parties (COP21) to avert climate catastrophe was crossed for the first time. However, the WMO indicated that while the temperature rise in 2024 temporarily exceeded the threshold, it did not signify failure to meet the goals of the Paris Agreement in the long term. According to numerous climate scientists, the onset of the El Niño event in 2023, which is characterized by abnormally warm sea surface temperatures in the eastern Pacific Ocean near the equator, led to a peak in global average temperatures in 2024 compared with the average temperatures of the pre-industrial periods. In 2024, under these circumstances, the Asia-Pacific region, which is vulnerable to climate change impacts due to continued global warming and extreme climate conditions, suffered huge human and material damages.

Heavy rains in China

Heavy rains in late April 2024, especially in southern China, caused significant human and property damage. The Chinese provinces of Guangxi and Guangdong received 200–280 mm of rain over three days (April 19–21, 2024), with the local cumulative precipitation exceeding 300 mm. Additionally, cloudbursts of 140 mm per hour and tornadoes were reported (see Figure 1).

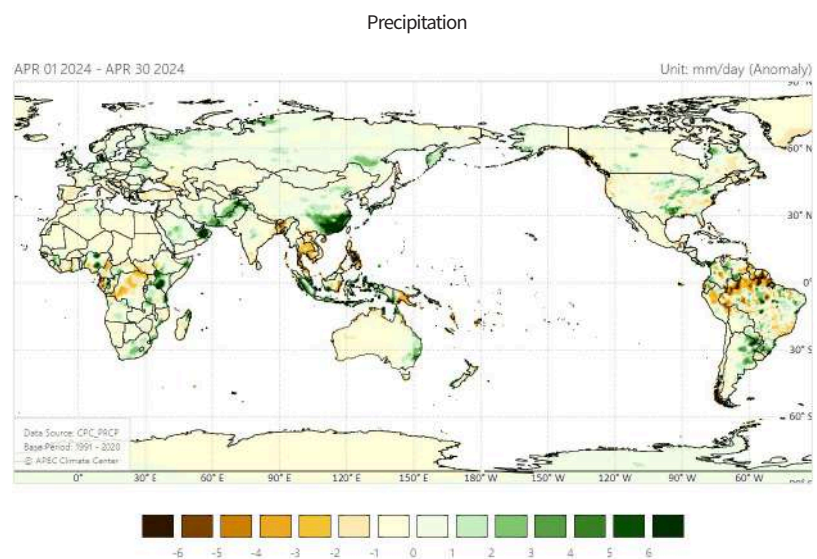


Fig. 1-1 Mean daily precipitation anomal in April 2024

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Extreme Climate in the Asia-Pacific Region in 2024

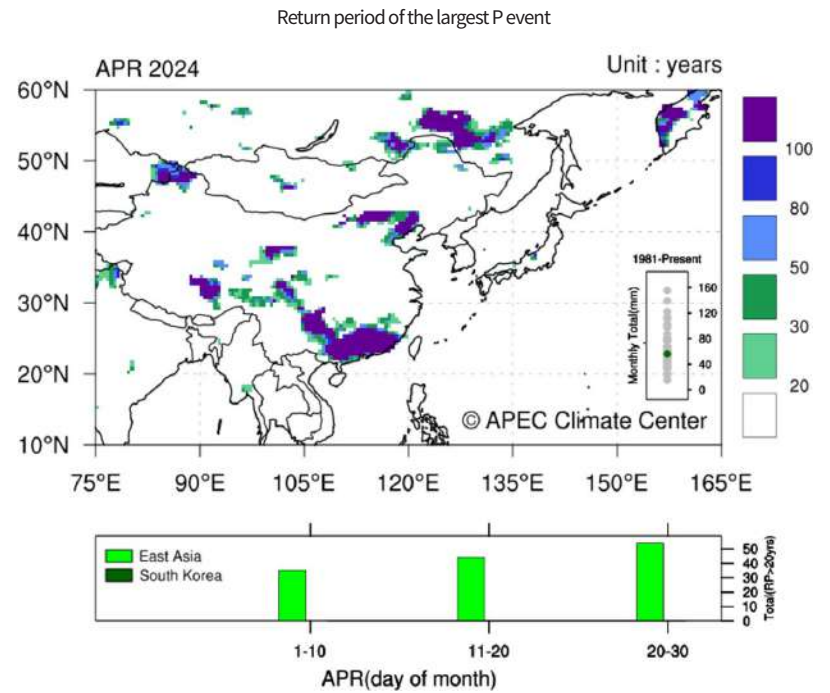


Fig 1-2 Return period of the largest precipitation event in April 2024

Furthermore, a relatively strong El Niño developed in the 2023/2024 winter, after which it weakened. In April, after the development of El Niño, a high-pressure circulation anomaly developed around the South China Sea, and East Asia was affected by hot and humid southerly winds. The distribution of the anomaly fields of the mean surface wind field in April 2024 showed a high-pressure circulation anomaly around the South China Sea, which resulted in higher precipitation due to the influx of hot and humid air from the tropics (see Figure 2).

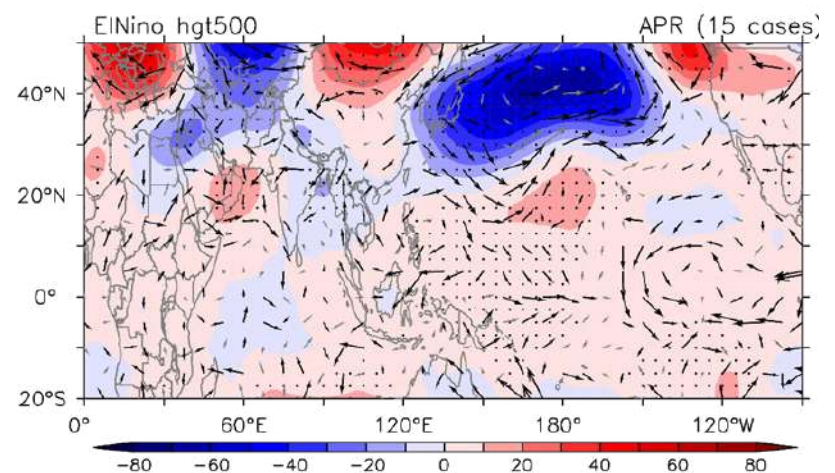


Fig 2-1 Distribution of the mean surface wind anomaly field in April 2024

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Extreme Climate
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in 2024

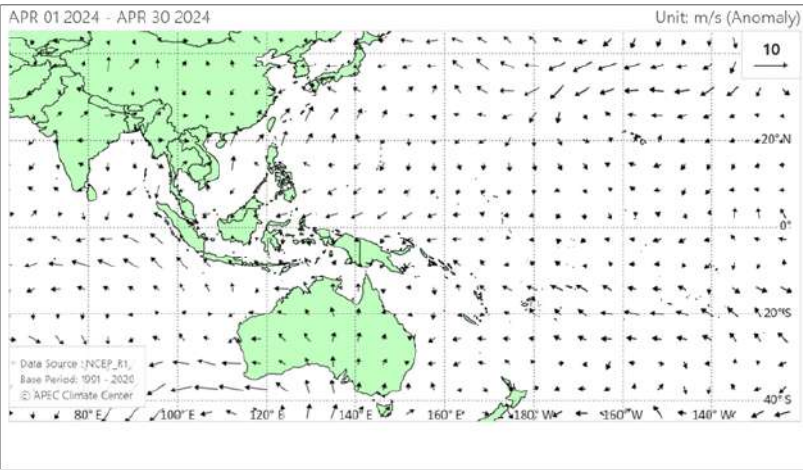


Fig2-2 Distribution of the mean surface wind anomaly field in April 2024

In April 2024, ¹⁾a negative North Atlantic Oscillation (NAO) developed in the North Atlantic Ocean. A structure with wave patterns appeared from Western Europe, the Urals, and Central Asia to China. The observed wave-like structure was analyzed to be related to the negative NAO (see Figure 3).

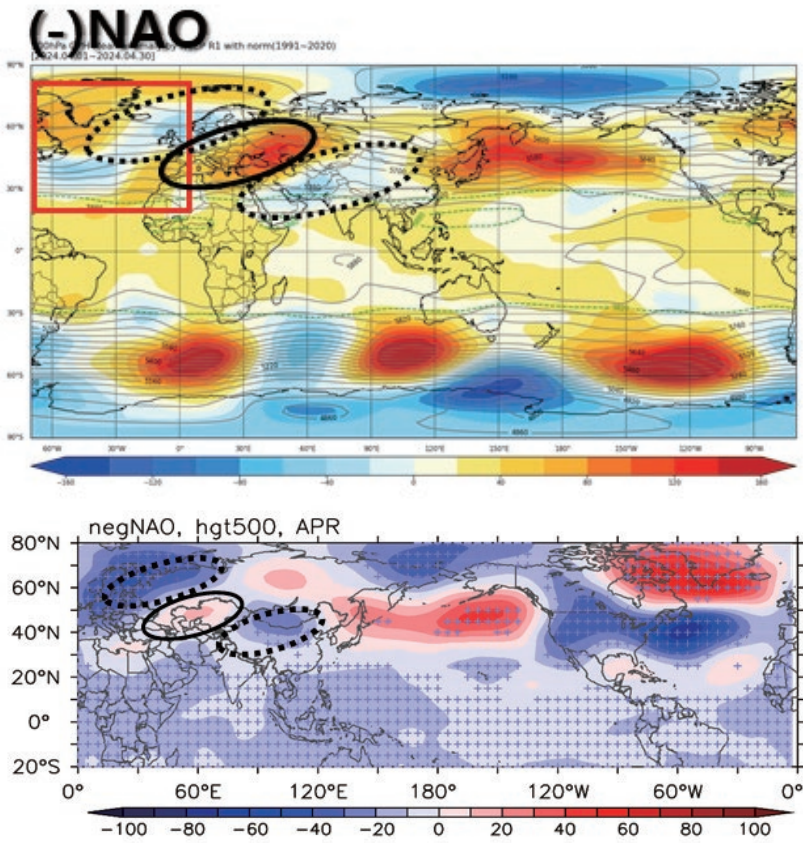


Fig 3 (top) Mean 500 hPa geopotential height anomaly field for April (Source: Korea Meteorological Administration); (bottom) Composite field distribution of 500 hPa geopotential height anomalies for the years with a negative NAO in April

1) North Atlantic Oscillation (NAO):

Fluctuations in the difference of atmospheric pressure between the Icelandic Low and the Azores High.

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Exreme Climate in the Asia-Pacific Region in 2024

The extended low-pressure circulation from Central Asia to China and the increased high-pressure flow associated with El Niño led to the convergence of hot and humid south-westerly winds over southern China, along with heavy rainfall in the region.

Meanwhile, the APCC's model tests has indicated that the ongoing surface temperature anomaly of the West Indian Ocean since the summer of 2023 is related to higher precipitation over western Central Asia. This increase was analyzed to be due to the precipitation over southern China.

In addition to natural variability, such as the El Niño decline,²⁾the Indian Ocean Dipole, and NAO, global warming driven by anthropogenic activities has been reported to have influenced the exreme increase in heavy rainfall in eastern China in April (³⁾Faranda et al. 2024).

High temperatures in Southeast Asia

Since early April 2024, record-breaking heat waves in Southeast Asia have forced schools to temporarily close, shorten school hours, and offer remote learning. Additionally, according to the Vietnam Meteorological and Hydrological Administration, 110 previous high-temperature records were broken in April alone. On the hottest day, April 27, 2024, the temperatures measured at five meteorological stations in Hanoi surpassed their previous highs; one station in particular reached 40.4 °C, far exceeding the previous high-temperature record of 37.8 °C (recorded on April 27, 1998) (see Figure 4).

Additionally, more than 50 people reportedly died in Thailand from heat-related illnesses due to the record-breaking heat wave of over 40 °C. The cultivation of durian, Thailand's main export, was also severely affected.

2) Indian Ocean Dipole (IOD)

A periodic fluctuation in sea surface temperature anomalies in the eastern and western parts of the tropical waters of the Indian Ocean between early summer and late fall. A positive dipole is characterized by warmer-than-normal sea surface temperatures in the Western part of the Indian Ocean and cooler-than-normal temperatures in the Eastern Indian Ocean. A negative dipole shows the opposite pattern.

3) Faranda, D., T. Alberti, F. M. E. Pons, & G. Mengaldo, 2024

April 2024 China floods exacerbated by both human-driven climate change and natural variability. Climate-Meter, Institut Pierre Simon Laplace, CNRS. <https://doi.org/10.5281/zenodo.14163532>. 2

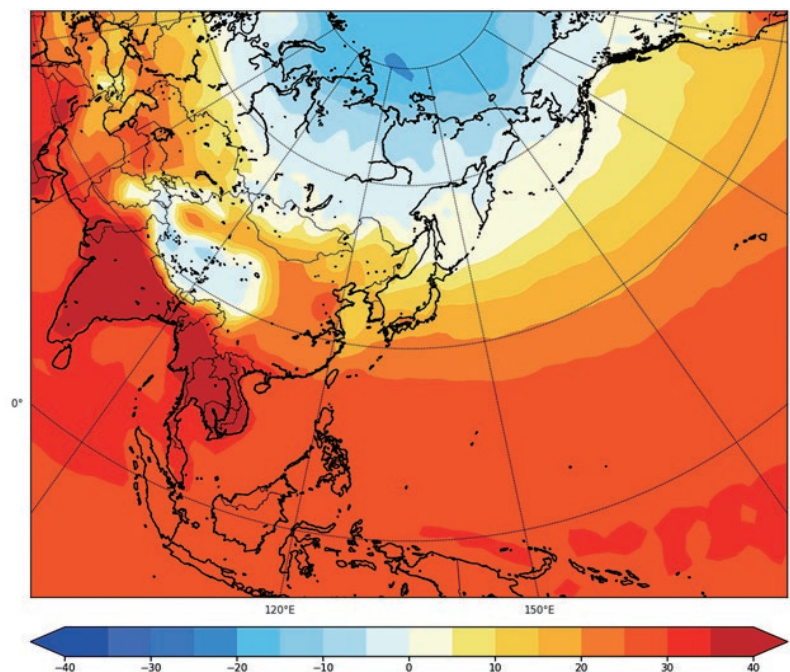


Fig 4-1 Mean maximum temperature in April (Source: Korea Meteorological Administration)

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Extreme Climate in the Asia-Pacific Region in 2024

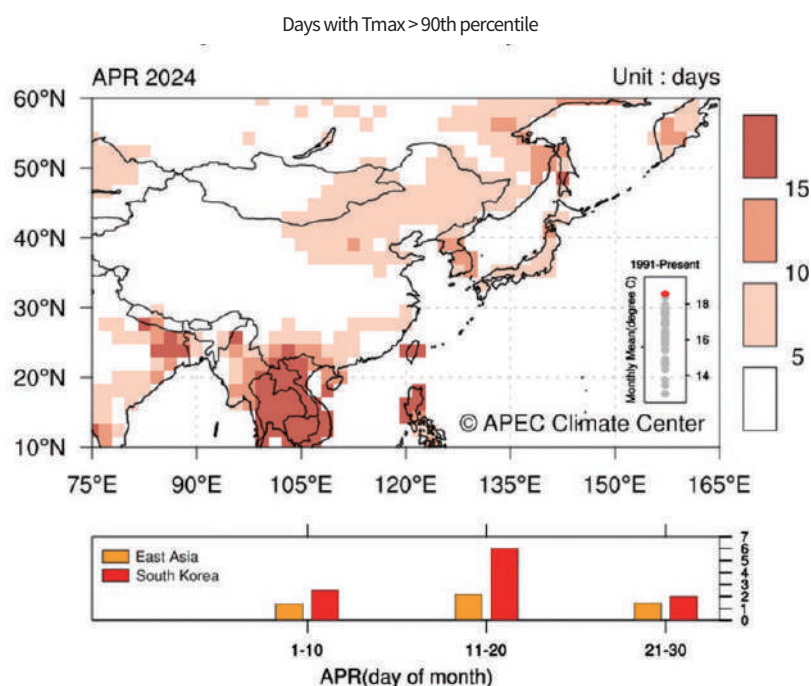


Fig 4-2 Number of days with maximum temperatures above the 90th percentile in Apr

After the development of El Niño, April was highly likely to be a month of high-pressure circulation anomalies around the South China Sea, with Southeast Asia under the influence of hot and humid southerly winds (see Figure 2). The distribution of anomaly fields in the mean surface wind field of April 2024 showed a high-pressure circulation anomaly around the South China Sea, with temperature increases under the influence of hot and humid air from the tropics (see Figure 2).

Meanwhile, recent studies have pointed out that April temperatures in Southeast Asia have generally been higher after the development of El Niño, and that April temperatures have been record high after the strongest El Niño on record (82/83, 97/98, 14/15). In other words, it has been reported that global warming has contributed to the higher probability of record heat waves (⁴Thirumalai et al., 2017).

Severe drought events were observed across most regions in Southeast Asia during the spring of 2024 (see Figure 5). The persistent drought in Southeast Asia heated the air above the soil, which increased the intensity of the heat wave due to the El Niño-related influx of hot and humid air.

Under the circumstances, the combination of global warming impacts, such as strong El Niño development in winter and extreme drought events starting in March, led to record-breaking heatwaves.

4) Thirumalai, K., P. N. DiNezio, Y. Okumura, and C. Deser, 2017

Extreme temperatures in Southeast Asia caused by El Nino and worsened by global warming. *Nature Communications*, 8, 15531.

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Extreme Climate in the Asia-Pacific Region in 2024

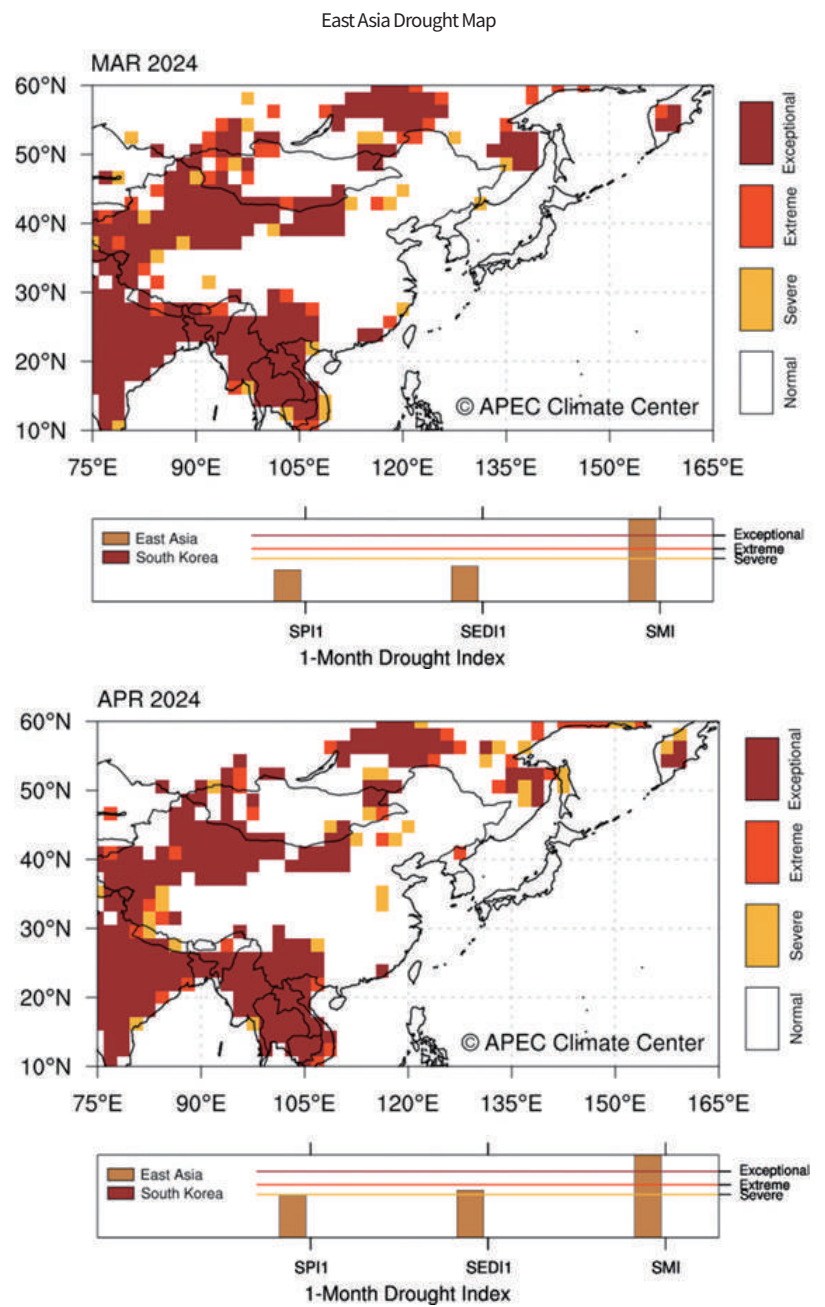


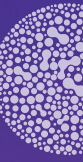
Fig. 5 Distribution of drought intensity in East Asia: (top) March 2024; (bottom) April 2024

02

APEC Climate Center



2024 Featured Achievements



2024 Featured Achievements

01

Establishment of Subseasonal Prediction Framework to Strengthen the Usability of Climate Information

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As extreme weather and climate events caused by global warming become more frequent, and the resulting social and economic damages increase, both domestic and international interest and demand for subseasonal prediction have grown significantly. In response, efforts are growing around the world to produce and utilize subseasonal prediction information through climate prediction models using various forms of international collaboration (such as WMO LC-SSPMME, SubC, and IRI). The APCC (APEC Climate Center), a specialized institution providing high-quality ¹⁾multi-model ensemble (MME) seasonal prediction information by collecting and integrating various seasonal prediction data, aims to extend its research to ²⁾subseasonal prediction to enhance the effectiveness and usability of its prediction information.

To achieve this, APCC implemented a two-year project from 2023 to establish a pilot system for developing an MME subseasonal prediction system. The project began with an assessment of the current status of domestic and international subseasonal prediction data and systems. Through various sensitivity experiments and the construction of a pilot system to integrate and produce different subseasonal prediction information, APCC established a subseasonal prediction framework (Fig. 7). In addition, APCC actively promoted international cooperation with seasonal prediction data providers to develop MME technology for subseasonal prediction and to collect real-time subseasonal prediction data. This study focused on the importance and efficiency of MME at the subseasonal level (Fig. 8, Fig. 9) and evaluated the applicability of APCC's climate prediction model (³⁾SCoPS) for subseasonal prediction. Through these efforts, APCC aims to enhance the reliability of climate predictions and expand their applicability across various sectors, ultimately providing seamless subseasonal to seasonal climate forecast information.

A comprehensive review was conducted based on the current status of domestic and international MME subseasonal forecasting systems and internal research. This review helped assess usability and establish criteria suitable for APCC's operational MME subseasonal forecast through various sensitivity experiments for processing daily data from individual models. Additionally, the potential for utilizing MME on a subseasonal level was diagnosed. During the 5th APCC MME Model Providers' Meeting, the possibility of securing subseasonal forecast data was explored, and real-time forecast information from some models was collected to develop a versatile and efficient pilot system consistent with the APCC MME seasonal forecast system. Furthermore, the potential use and improvement direction of the SCoPS model for subseasonal forecast were established through trial production of subseasonal forecasts using APCC's in-house model (SCoPS) and comparative evaluation of predictive power with S2S project (Subseasonal-to-Seasonal Prediction Project) models.

1) Multi-Model Ensemble (MME)

To disseminate seasonal forecast data to the Asia-Pacific region, the APCC applies MME techniques to climate prediction models provided by 16 climate prediction agencies from 11 countries. The MME method improves the accuracy of climate predictions by integrating the prediction information from each climate prediction model provided by climate prediction agencies and eliminating errors.

2) Subseasonal Prediction (or Forecast)

Climate forecasts for a period ranging from 2 weeks to 2–3 months

3) SCoPS (Seamless Coupled Prediction System)

APCC's in-house global climate prediction model

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Establishment of Subseasonal Prediction Framework to Strengthen the Usability of Climate Information



Fig. 6 The 5th APCC MME Model Providers' Meeting (Aug. 29- Sep. 1, 2023, Busan)

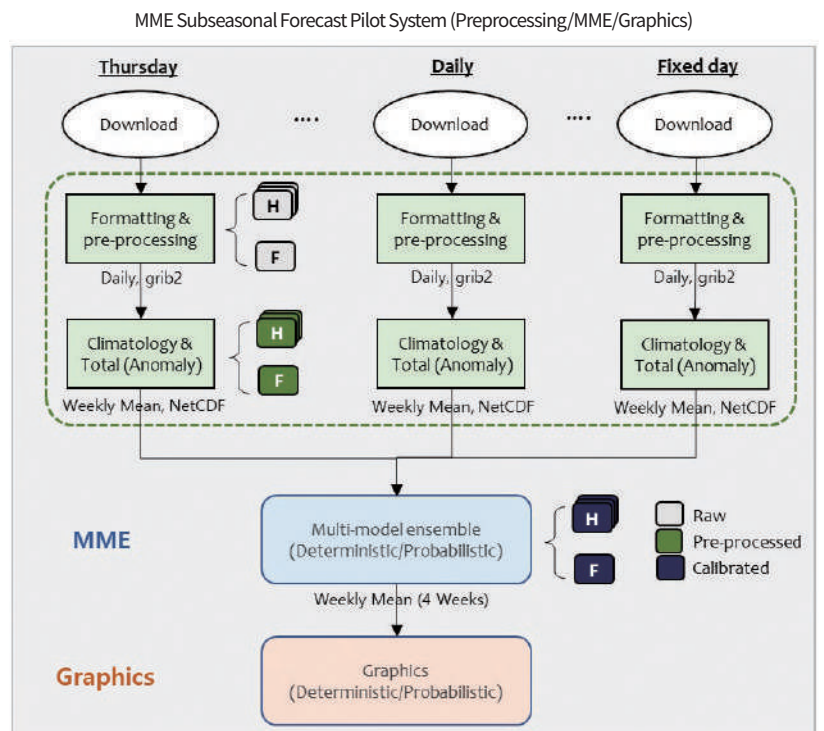


Fig. 7 MME subseasonal forecast procedures in pilot system

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Establishment of Subseasonal Prediction Framework to Strengthen the Usability of Climate Information

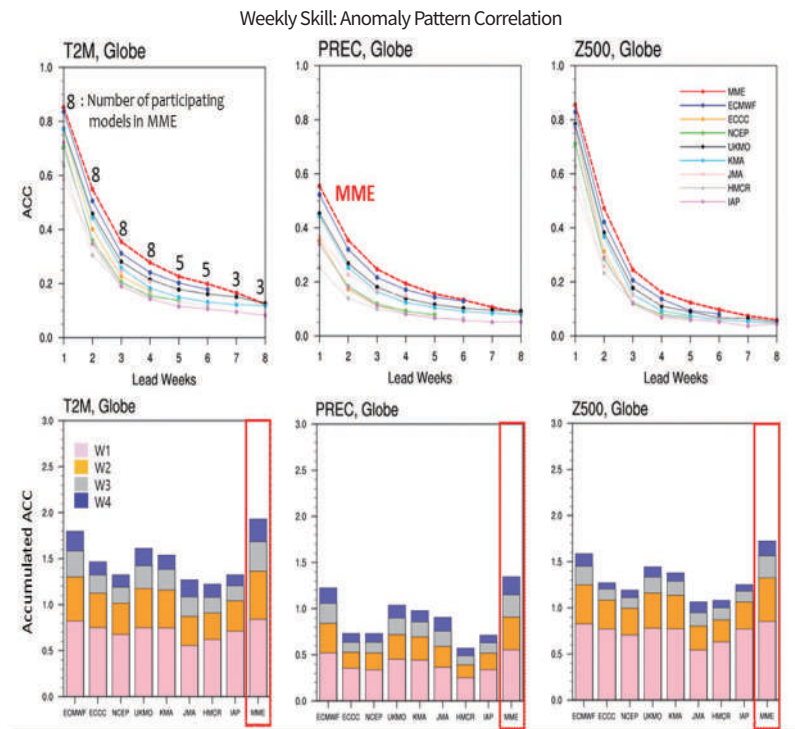


Fig. 8 (Upper) Weekly ACCs (1-8 weeks) and (Lower) accumulated ACCs (1-4 weeks) of the global temperature, precipitation and geopotential height at 500hPa from 8 individual models and their simple averaged MME (MME target forecast day : Monday)

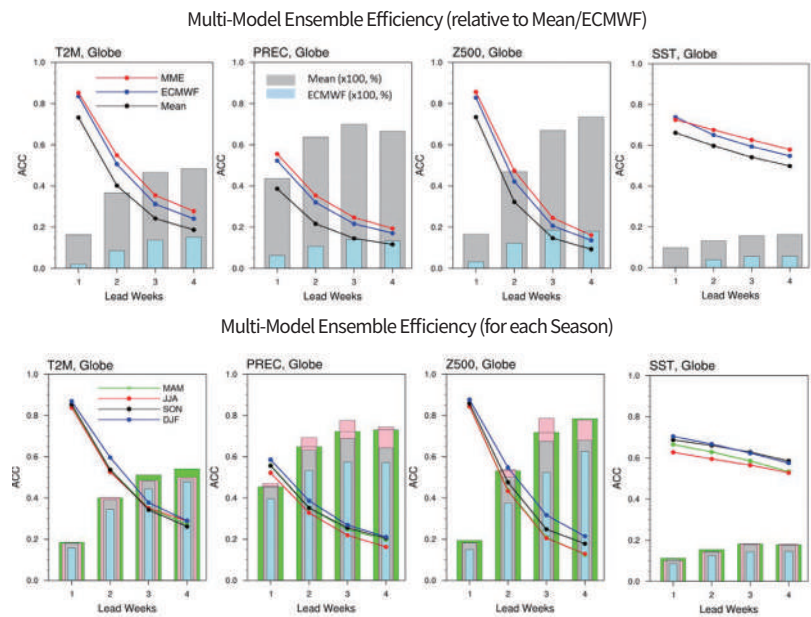


Fig. 9 (Upper) Weekly ACCs of temperature, precipitation, geopotential height at 500hPa, and sea-surface temperature for each MME, ECMWF, and mean of 8 models (Mean) and MME efficiency relative to ECMWF/Mean (Lower) Weekly ACCs of temperature, precipitation, geopotential height at 500hPa, and sea-surface temperature for each season (MAM, JJA, SON, and DJF) from MME and MME efficiency relative to ECMWF

We plan to encourage model improvement and promote the expansion of participating models among model providers to establish a framework for producing MME subseasonal to seasonal prediction information and strengthen the cooperation network. This is expected to produce and provide high-quality subseasonal prediction information, contributing to the support of medium- to long-term forecasts in the Asia-Pacific region.

02

Improving Long-term Forecasts by Selecting and Focusing Information

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Over the past several years, APCC has been working to improve the accuracy of long-term forecasts in the field by strengthening the support system based on the cooperation system with the KMA. The three-year, six-step Asia-Pacific project from 2022 to 2024 tried to build on the existing APCC-KMA cooperation system and further expand the scope of APCC's role in long-term forecasting. To this end, we attempted to improve the current forecasting technology in long-term forecasting practice and to lay the foundation for producing objective forecasting information by selecting and processing previously developed technology or improved climate information ([information with good predictability](#)). As a result, we have prepared integrated monitoring and forecasting information and utilization guidelines for winter forecasting.

To establish integrated monitoring and prediction information and utilization guidelines for winter forecasting, we considered the model reproducibility for each of the observational monitoring factors and decided whether to reflect the signals from the observational monitoring factors in the forecast. In other words, higher model reproducibility indicates a lower importance of the observational monitoring factor, while lower model reproducibility indicates a higher importance of the observational monitoring factor. Thus, we presented the integrated information and utilization guidelines for monitoring and forecasting for monthly temperature forecasting in winter. Through this work, we comprehensively considered the model reproducibility of observation data ([tropical oceans, North Pacific, Eurasian continent, and Arctic](#)) that affect winter temperatures in South Korea, objectively deciding whether to incorporate signals based on observation data into South Korea's forecasts, ultimately enabling more confident seasonal predictions.

Currently, 3-month forecast data is produced by adding observational monitoring factors to the model forecast information, and the monitoring factors used are included in the long-term forecast guidance. Despite the fact that the long-term forecast guidance contains a lot of information, the significance of the information is unclear for monthly forecasts. In particular, there is insufficient information on model characteristics to directly use observational monitoring factors in model forecasts. Therefore, a lot of information needs to be screened and calibrated to solve this problem. In this study, we propose a method to select and calibrate model prediction information by considering the model reproducibility for the variability and impact of monitoring factors to improve long-term forecasting. Considering the current long-term forecasting system, the following questions were derived. First, how much do we know about the model characteristics? Second, how robust is the monitoring factor information? Third, are the criteria for selecting the information clear? Fourth, can we minimize the subjective judgment of forecasters in producing the forecast? Consequently, the direction for improving long-term forecasts in this study is to find the answer to these questions.

The ultimate goal of the challenge is "traceable, reproducible, and physically intuitive forecasts," which is what the WMO strives for in its objective seasonal forecasts. In a broad sense, it is not different from the current APCC long-term forecasts, especially in terms of integrating model projections with observational monitoring ([Fig. 10](#)). For objective forecasting, it is necessary to understand the model predictability itself, select the optimal method for long-term forecasting in Korea, and then select and integrate observational monitoring information based on this. Therefore, in this project, we examined how observational monitoring information is selected and integrated, how it is reproduced in long-term

02 Improving Long-term Forecasts by Selecting and Focusing Information

forecast models, and proposed a way to integrate it. As measures to improve the 3-month long-term forecast, we 1) identified the reliability of model information to select useful information for long-term forecasting in Korea, 2) selected key climate monitoring factors in winter and diagnosed their usefulness (Fig. 11), and 3) proposed a method for combining key climate monitoring factors and model information in winter. Accordingly, we proposed a long-term forecast decision-making plan based on highly reliable (*predictive and useful*) model and monitoring information, and directly utilized the results to produce long-term forecast outlooks for Korea. Through this series of studies, we first improved the understanding of model characteristics, then selected robust surveillance information, defined clear criteria, and finally minimized the subjective judgment of forecasters.

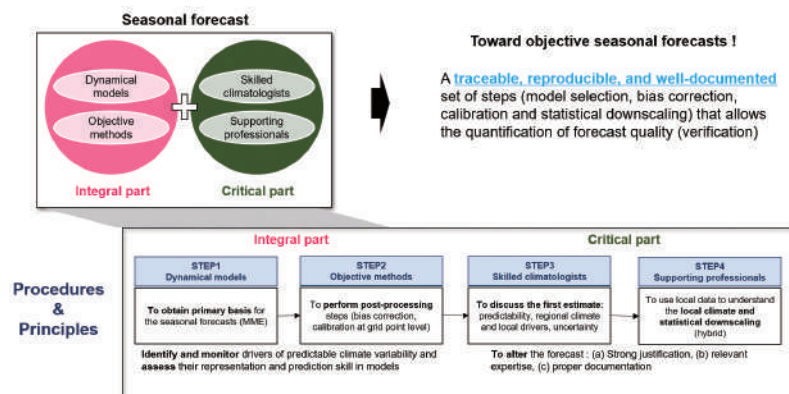


Fig. 10 How to combine predictive and observed information

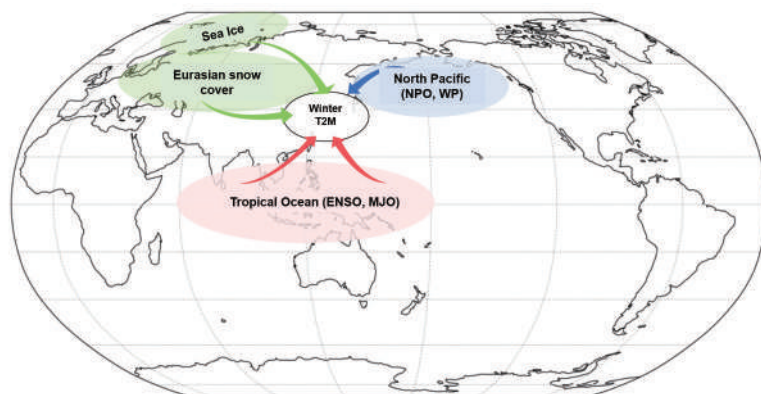


Fig. 11 Key climate monitoring indicators in winter

In order to improve the predictability of Korea's long-term forecasts, we aimed to produce forecast information that reflects the status and trends of climate monitoring factors affecting Korea along with the forecast information produced by the model. To this end, various climate analysis results and monitoring predictors have been developed and utilized, but there is a lack of information on the relevance and priority of the factors. In addition, there is room for selective interpretation of the information based on the subjective judgment of forecasts in current long-term forecasts. Therefore, to improve long-term forecasting in Korea, we will select observational monitoring factors while also reflecting the model prediction characteristics of these factors, thereby contributing to the practice of long-term forecasting.

03

Improvement of The KMA Climate Prediction System Using High- Resolution River Routing Model

Dr. Suryun Ham suryun01@apcc21.org

Climate prediction systems are continuously advancing to enhance mid- to long-term forecasts, ranging from subseasonal to seasonal timescales. Over the past several years, APCC has been conducting research to enhance the Korea Meteorological Administration (KMA) climate prediction system (GloSea6) through a research and development hub comprising the National Institute of Meteorological Sciences (NIMS) and academic institutions. In particular, APCC acts as a bridge for Research-to-Operations (R2O) by conducting semi-operational experiments and evaluating the applicability of technologies developed in academia. In addition, efforts are underway to improve the KMA climate prediction system by assessing and diagnosing the model's systematic characteristics and developing suitable improvement technologies.

Understanding the model's predictive characteristics and identifying weaknesses are critical in enhancing climate prediction systems. The water cycle, an important process in the climate prediction system, circulates between land and ocean through evaporation driven by solar radiation, the transport of water and water vapor by wind, and precipitation resulting from cloud formation. Precipitation on land is temporarily stored as snow or soil moisture, or flows into a river basin and is eventually delivered to the ocean as freshwater. This is considered the largest flow that represents the global water cycle. In particular, it is well known that freshwater flowing from land into the ocean directly impacts ocean salinity, altering water density, the mixed layer, and sea surface temperature, which in turn affects air-sea interactions. Therefore, this study aimed to identify the characteristics of the river routing processes included in KMA GloSea6, with the ultimate goal of improving the global water cycle.

Currently, within GloSea6, river flow is calculated using the Total Runoff Integrating Pathways (TRIP; Oki and Sud, 1998). The river routing model calculates the discharge from each model grid and ultimately transfers it to the ocean grid. In GloSea6, the river routing model is coupled to the atmosphere and ocean models. The atmospheric resolution is set to about 0.7 degrees and the ocean resolution is set to about 0.25 degrees, while the river model is set very low at about 1 degree. While the current low resolution may be adequate for modeling flow in large global basins, it has limitations in accurately representing regionally distributed natural rivers. To accurately represent river flow and the interactions between the atmosphere, land, and ocean, it would be ideal to incorporate a more detailed and complex river model. However, we attempted to suggest an improvement direction through a simple method of increasing the resolution of the currently used river routing model.

To this end, the river flow data, which is currently fixed at a resolution of 1 degree, was newly constructed to be calculated at resolutions of 0.5 degrees and 0.125 degrees as input data for GloSea6, and the module was newly configured to be applicable to the river routing process (Fig. 12). Furthermore, based on various sensitivity experiments, GloSea6 with the high-resolution river routing model was optimized to establish a foundation for practical use. The results of the GloSea6 experiment with the high-resolution river routing model show reduced errors in flow and river discharge compared to the results of the existing resolution. Notably, it alters ocean flow, leading to improvements in sea surface temperature along the coast of the Korean Peninsula (Fig. 13).

03

Improvement of the KMA Climate Prediction System Using High-Resolution River Routing Model

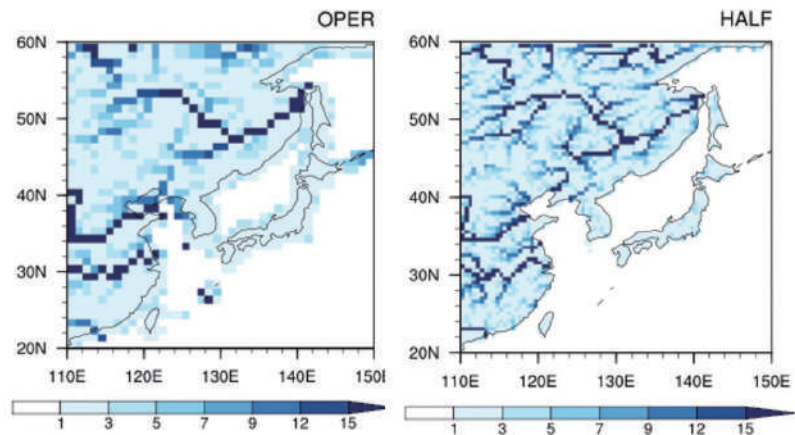


Fig. 12 River flow input data (river sequence) for the current resolution at 1 degree (OPER) and the newly conducted resolution at 0.5 degree (HALF)

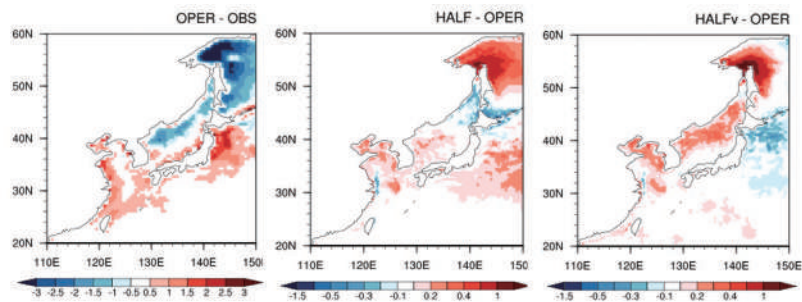
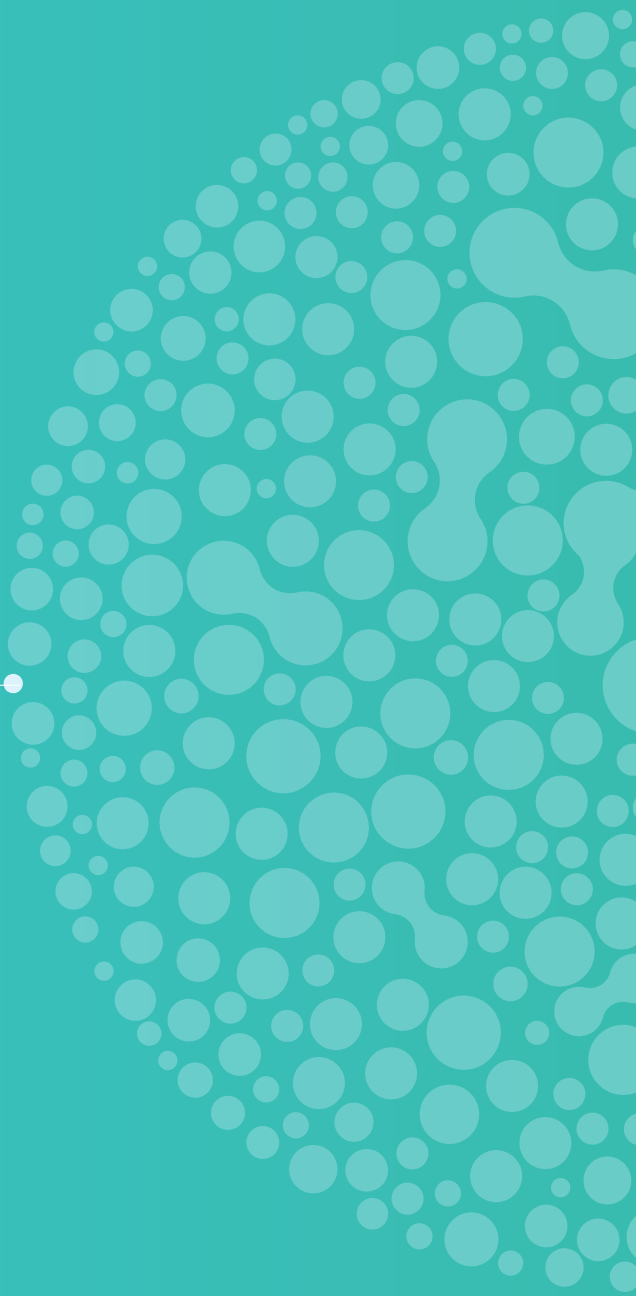


Fig. 13 Accessing the prediction feature of summer sea surface temperature for the default experiment with resolution 1 degree (OPER), the newly conducted experiment with resolution at 0.5 degree (HALF), and optimized experiment with resolution at 0.5 degree (HALFv)

It is challenging to represent river flow using hydrological information simulated at the existing resolutions, in a small-scale area like Korea. The KMA climate prediction system, which incorporates the newly constructed high-resolution river routing model, is expected to significantly reduce errors in sea surface temperatures along Korea's coast. Additionally, changes in air-sea interactions could enhance global seasonal prediction skill and be valuable for regional water resource applications and policy research.

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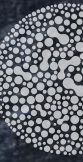


03

APEC Climate Center



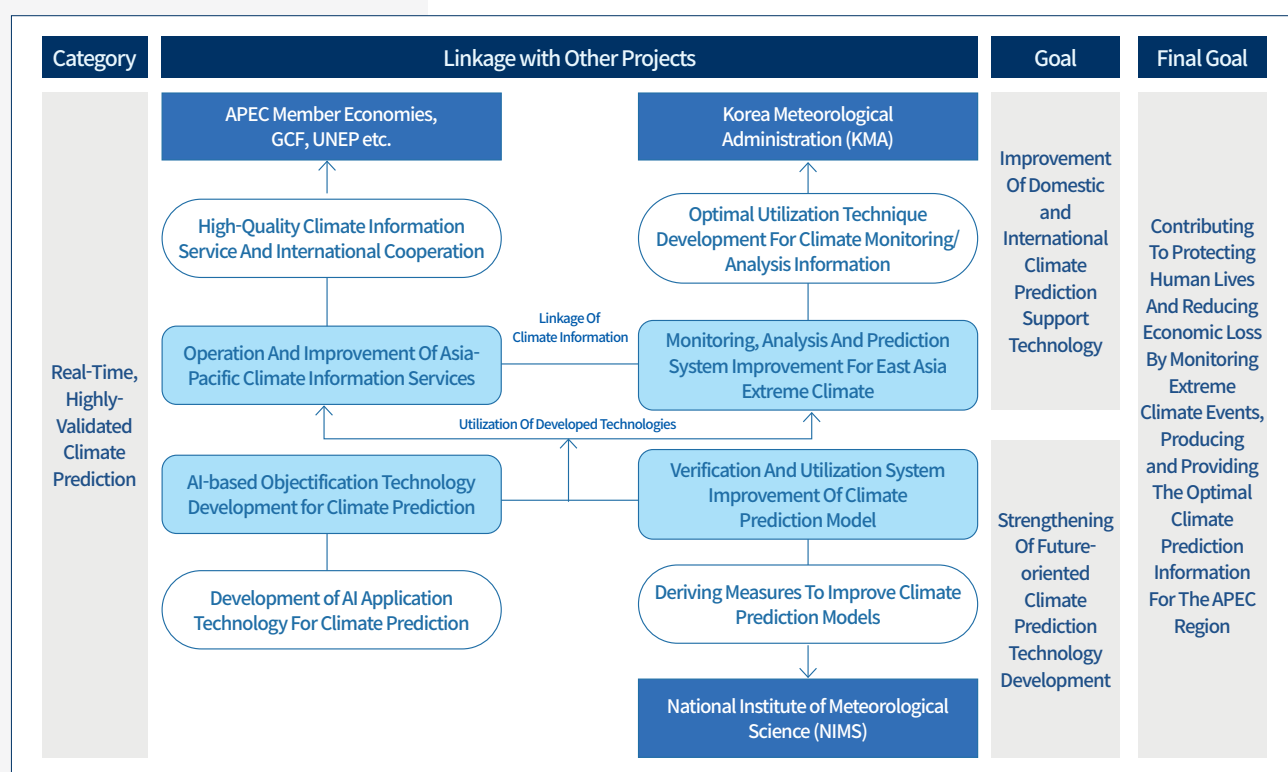
2024 Research Projects



2024 Research Projects

Improving the Structure of Climate Information Service for the Asia-Pacific Region And Establishing An Innovation System for Climate Prediction Technology to Strengthen Climate Crisis Response Capacity

Category	Subcategory	Project Name
1. Real-Time, Highly Validated Climate Prediction	1-1. Operation And Improvement Of Asia-Pacific Climate Information Services	Project 1. Establishment Of High-resolution Multi-Model Ensemble (MME) Subseasonal To Seasonal (S2S) Prediction Framework And Diversification Of Web Contents To Strengthen The Usability Of APCC Climate Information
		Project 2. Development Of APCC Dynamic Climate Information Services
	1-2. Monitoring, Analysis And Prediction System Improvement For East Asia Extreme Climate	Project 3. Developing Techniques To Utilize Predictive Information To Improve Long-term Forecasts
		Project 4. Enhancing Climate Information And Establishing Integrated Information System To Cope With Extreme Climates
	1-3. Artificial Intelligence (AI)-based Objectification Technology Development For Climate Prediction	Project 5. The Development Of Artificial-Intelligence-Based Technologies For Objective Climate Prediction (III)
	1-4. Verification And Utilization System Improvement Of Climate Prediction Model	Project 6. Testbed Construction and Development Of Its Utilization Technology For The National Climate Prediction Model
2. Green Climate Fund (GCF) Supported Projects	2-1. Project Initiated By The UN Environment Programme (UNEP)	Project 7. Enhancing Climate Information And Knowledge Services For Resilience In 5 Island Countries of the Pacific Ocean



01

Real-Time, Highly Validated Climate Prediction

1) Multi-Model Ensemble (MME)

To disseminate seasonal forecast data to the Asia-Pacific region, the APCC applies MME techniques to climate prediction models provided by 16 climate prediction agencies from 11 countries. The MME method, by integrating climate forecast models to minimize uncertainty, generally improved the predictive power of various models.

2) Boreal Summer Intraseasonal Oscillation (BSISO)

Convection phenomenon that occurs in the Indian Ocean with a 15–60-day cycle and propagates northward while exhibiting Rossby wave-like character. This phenomenon affects the onset of the Asian summer monsoon season, atmospheric circulation, and weather.

3) Subseasonal Prediction (or Forecast)

Climate forecasts for a period ranging from 2 weeks to 2~3 months

4) El Niño-Southern Oscillation (ENSO)

An irregularly periodic variation in winds and sea surface temperatures over the tropical eastern Pacific Ocean, affecting the climate of much of the tropics and subtropics. The warming phase of the sea temperature is known as El Niño, while the cooling phase as La Niña.

5) Seamless Coupled Prediction System (SCoPS)

APCC's in-house global climate prediction model

Overhauling the Asia-Pacific Climate Service and Establishing Climate Prediction Technological Innovation System to Strengthen Climate Crisis Response Capabilities

1-1. Operation And Improvement Of Asia-Pacific Climate Information Services

- ◎ Securing APCC MME competitiveness and strengthening user support for climate information service

Project 1. Establishment of High-resolution Multi-Model Ensemble (MME) Subseasonal to Seasonal (S2S) Prediction Framework and Diversification of Web Contents to Strengthen the Usability of APCC Climate Information

Dr. Bong-Geun Song songbg@apcc21.org

1) Background and Necessity

- Stable operation and improvement of the APCC climate prediction system to provide high-quality real-time climate prediction information for Korea and the Asia-Pacific region
- Providing diverse user-friendly climate information web content and establishing a foundational System for subseasonal to seasonal (S2S) prediction time scale expansion

2) Main Contents

A Operation of the APCC climate prediction system and Provision of Prediction Information

- ¹⁾ MME seasonal forecast: Dissemination of global/Pacific Island climate outlooks in English and Korean around the 15th of each month
- Probabilistic seasonal forecast for East Asia: Provision of forecast information on the website around the 15th of each month
- ²⁾ BSISO ³⁾ subseasonal forecast: Production and provision of BSISO information (May to October)
- ⁴⁾ ENSO alert: Updates provided twice a month (around the 15th and end of the month)
- ⁵⁾ SCoPS seasonal forecast: Monthly production of SCoPS information and participation in MME
- Early warning for Southeast Asia wildfire forecast: Production and provision of precipitation and wildfire prediction advisories for Indonesia (April to July) and Malaysia (October to January)
- Presentation material for KMA forecast discussions: Preparation of presentation materials including MME seasonal forecast results for the Korean Peninsula

B Improvement of the APCC climate prediction system

- Automation of East Asia MME Temperature Seasonal Prediction Bias Correction
 - Development of an automated system for bias correction of both individual models and MME deterministic/probabilistic temperature predictions
- Enhancement of BSISO subseasonal forecast system
 - Reproduction of composites due to changes in observational data (OLR daily data).

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- Improvement of SCoPS seasonal forecast system
 - Extension of the hindcast period (1982–2013 → 1982–2016)
- Enhancement of Southeast Asia wildfire prediction system
 - Trial development of a grid information production system to provide detailed information for wildfire prediction regions
- Improvement of climate information web content on the website
 - Addition of selective display functionality for climate standard normals (1981–2010 and 1991–2020)

C Development of a foundational system for MME subseasonal forecast

- Establishment of an operational foundation for subseasonal forecast through international cooperation
- Establishment of a foundational system for SCoPS subseasonal forecast data production
- Foundational research for operationalization of MME subseasonal prediction

D International Cooperation and Policy Support in the Climate Field

- Operation of the WMO Lead Centre for Long-range Forecast and support for the publication of the Global Seasonal Climate Update (GSCU)
- Support for and participation in Regional Climate Outlook Forums (RCOF)

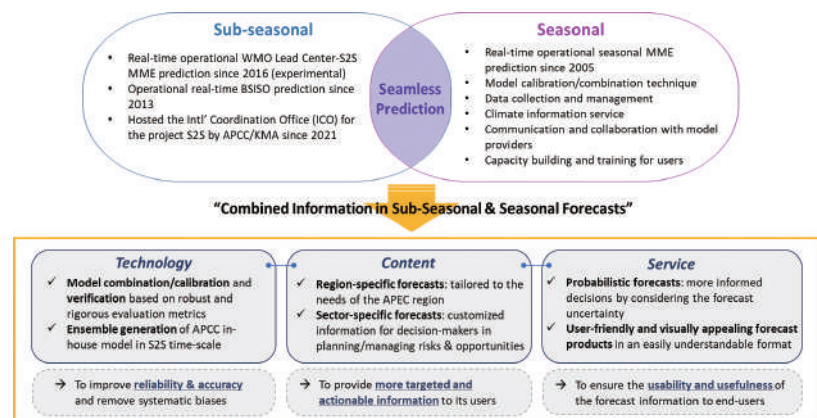


Fig 14 APCC's strategic approach for providing seamless subseasonal to seasonal climate forecast information

3) Expected Effects

- Stable Operation and continuous system improvement for the production and delivery of high-quality climate forecast information
- Development of core technologies and operation of subseasonal forecast through the establishment of an MME subseasonal forecast System
- Strengthening international climate networks through collaboration with APCC MME model providers, WMO, and Others.

Project 2. Development of APCC Dynamic Climate Information Services

Dr. Hyunrok Lee tank@apcc21.org

1) Background and Necessity

- Service Operation: To ensure stable operation and continuous improvement of the APCC Climate Information Service based on the annual operational plan.

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1) Mashup Service

A service that enables the creation of new climate services by integrating climate data production, processing, and provision. It supports users in producing seasonal forecast data, extracting regions, and downloading data through standardized Open APIs.

2) Climate Information Service Platform CLIK (CLimate Information toolKit)

A platform that allows users to select individual climate models, prediction variables, forecast regions, and analytical methods to produce, process, and provide climate forecast and verification information

- User Support: To diversify user support for the APCC Climate Information Service by establishing an Open API package based on the climate information service platform.
- Establishment of Dynamic Climate Information Service: To establish an integrated interface with the APCC homepage for a dynamic, one-stop climate information service, providing tailored high-resolution climate forecast data to users.

2) Main Contents

A Diversification of Dynamic Climate Information Services and User Support

- Integration of the Climate Information Service Platform and the APCC homepage
 - Development of web interfaces for ¹⁾mashup services of the climate information service platform
 - Integration of the ²⁾Climate Information Service Platform (CLIK) and the APCC homepage
- Expansion of dynamic service content on the website:
 - Enhancement of website services with the production and provision of static and dynamic climate information

B Stable Operation and Improvement of the APCC Climate Information Service

- Stable operation of the climate information services:
 - Ongoing operation and updating of the APCC climate information services (website, platform, etc.)
 - Development and regular inspection of the operation plan for the climate information services (monthly)
 - Security improvements to address vulnerabilities in the climate information services
 - Continuous monitoring via the climate information service monitoring system
 - Support for relevant tasks needed for service operation (e.g., information resource management, quality control, public data, data-based administration)
- Official service for high-resolution, user-customized MME climate prediction information
- Establishment of an Open API package based on the climate information service platform:
 - Design and implementation of Open API technology for the service unit combinations of the climate information service platform
 - Development and release of a one-stop Open API support package
- Updating the AIMS internal backend/frontend programs

Development of Integrated web interface for APCC Homepage and Climate Information Platform

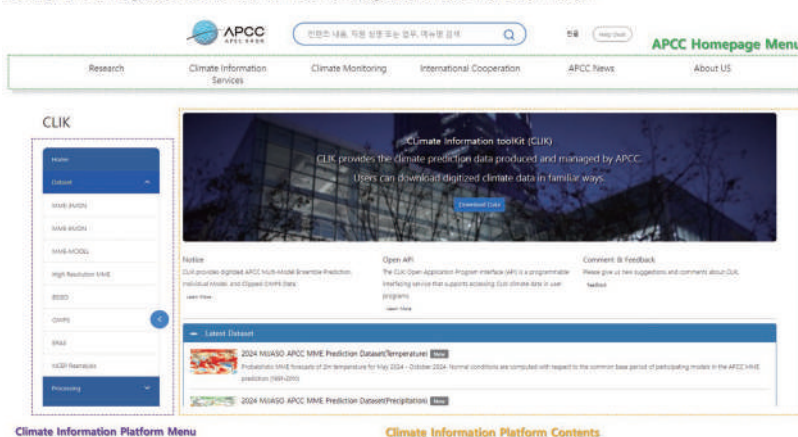


Fig. 15 Integration of the Climate Information Service Platform (CLIK) and the APCC homepage

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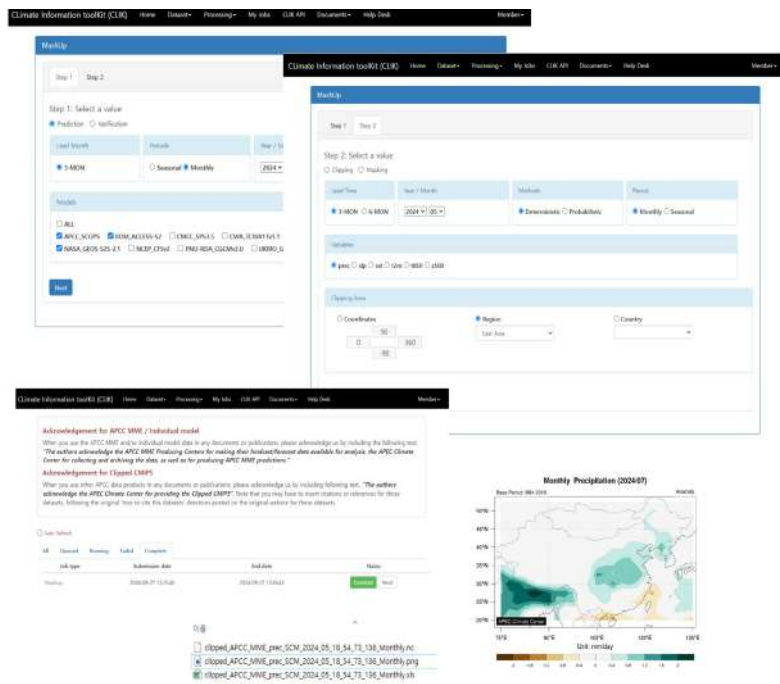


Fig. 16 System Architecture for Mashup Services

Mashup System Architecture

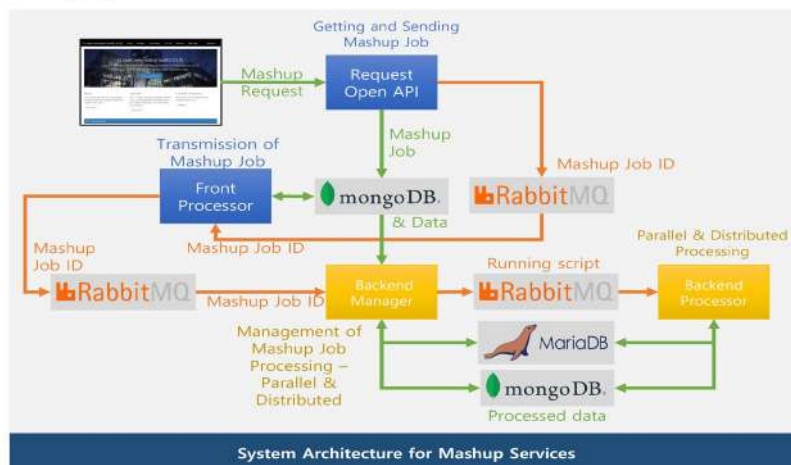


Fig. 17 Development of web interfaces for mashup services of the climate information service platform

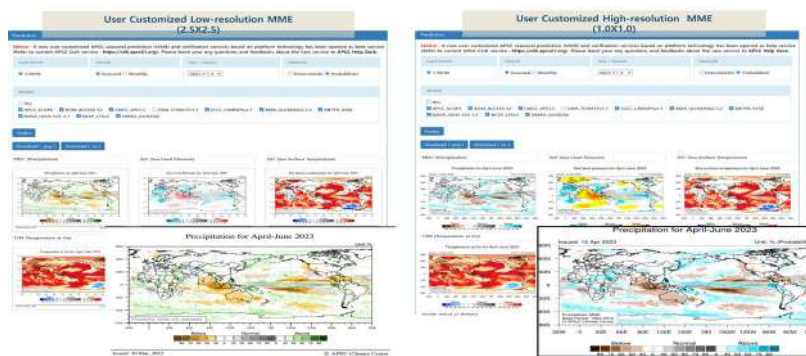


Fig. 18 Official service for high-resolution, user-customized MME climate prediction information

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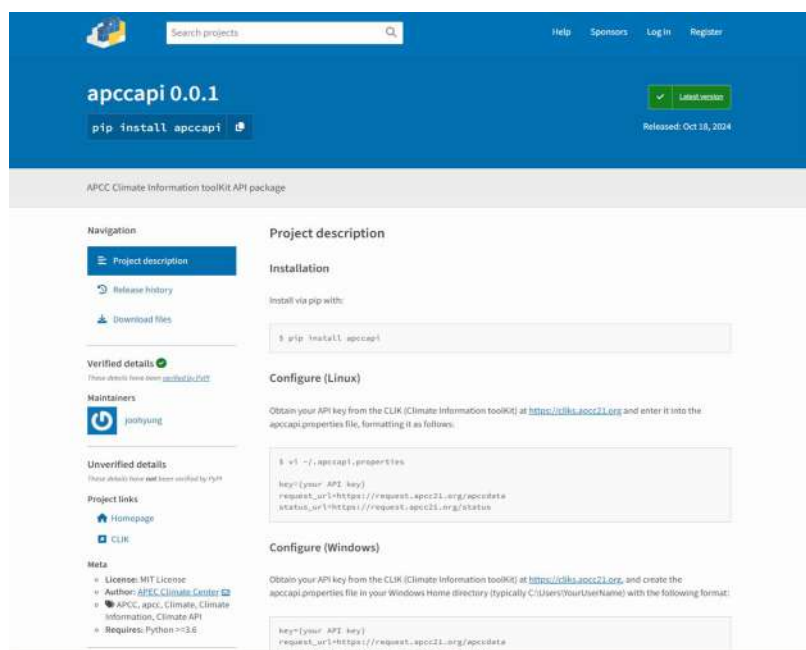


Fig. 19 Development and release of a one-stop Open API support package

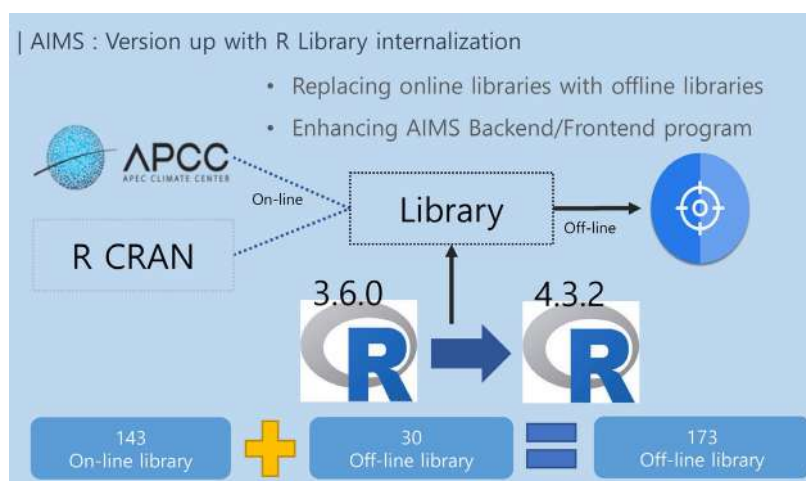


Fig. 20 Updating AIMS internal backend/frontend programs for system maintenance

3) Expected Effects

- Enhanced user accessibility and strengthened climate information delivery channels through the expansion of climate data, dynamic climate information provision, and consistent information delivery.
- Support for domestic private and public institutions, as well as the Asia-Pacific region, through the production, processing, and provision of climate prediction/verification data using the climate information service platform.
- Improvements in the stability, scalability, and cost-efficiency of the APCC Climate Information Service through cloud platform technology.
- Enhancement of the usability of APCC climate prediction information through the mashup service establishment and the integration of the agency's website with climate information services, including the creation of user-participatory climate information.

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1-2. Monitoring, Analysis And Prediction System Improvement For Extreme Climate In East Asia

- ◎ Development of optimal utilization techniques for information on prediction, monitoring and analysis

Project 3. Developing Techniques to Utilize Predictive Information to Improve Long-term Forecasts

Dr. OkYeon Kim oykim@apcc21.org

1) Background and Necessity

- To select and process highly predictive information from various observations and model-based information to produce more objective predictive information
- To evaluate and synthesize observational and model information used for long-term forecasting and provide guidance for its use

2) Main Contents

A Development of technology to leverage model-based forecasts to support winter long-term outlooks

- Selecting additional predictors for winter and analyzing the reproduction properties of seasonal forecast models for additional factors
 - Selecting additional observation-based predictors and analyzing model reproducibility
 - Analyzing associations between predictors and providing guidance on how to utilize predictive information
- Developing a model of Korea's influence on tropical convection
 - Analyzing BSISO/MJO forecast performance and significance of atmospheric circulation patterns
 - BSISO/MJO impact map climate forecast and internal system application (weekly)

B Cooperation to improve climate prediction information

- Production of forecasts and information to support the production of the KMA 1/3-month outlook (year-round)
 - Production of APCC 1-month forecast results
 - Producing and providing 1-month temperature forecasts using deep learning models
 - Attending 3-month outlook meeting and briefing APCC MME and analytics-based forecasts results
 - Producing and providing monthly/regional 3-month tercile probability forecasts with Gaussian processes
 - WMO long-range forecast leading center (1-month outlook, year-round)

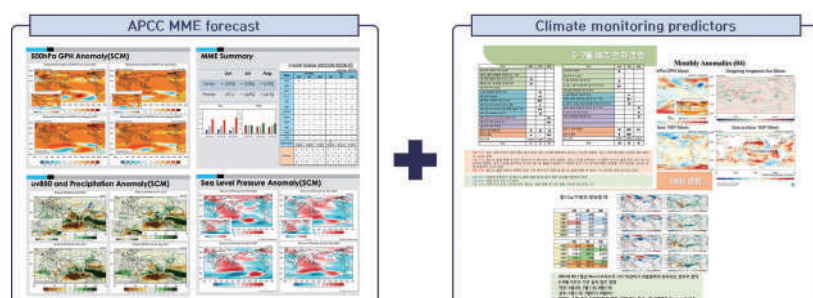


Fig. 21 APCC long-term forecast production system concept

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Real-Time, Highly Validated Climate Prediction

3) Expected Effects

- Building skills and experience in producing KMA 1/3-month forecasts
- Strengthening APCC-KMA partnership through practical cooperation on 1/3-month outlooks

Project 4

Enhancing Climate Information And Establishing Integrated Information System To Cope With Extreme Climates

Dr. Seon Tae Kim seontae.kim@apcc21.org

1) Background and Necessity

- Reliable predictions of extreme climate events around the world, which have recently become more frequent and stronger due to climate change caused by global warming, are important to address climate change.
- APCC has been striving to produce reliable observation-based predictive information by dynamically analyzing major climatic factors influencing temperature and precipitation variability in Korea.
- The relationship between Korean climate and its predictors, and the use of predictors just based on simple correlations has limitations in improving the capability of predictor-based prediction.
- An appropriate method is necessary for the various climate predictors to contribute to improving seasonal predictions and preparing for climate change.
- In order to adapt to and prepare for climate change, research is needed on abrupt temperature drops during winter that affects public health.
- The Climate Analysis System (CAS) needs improvement to provide timely analysis and information related to extreme climate events while considering user convenience.

2) Main Contents

A Improvement of observation-based predictive information through the development of winter climate predictors and analysis of its related dynamical processes.

- The impact of Atlantic and mid-latitude wave propagation on January temperatures in Korea.
 - The mid-latitude atmospheric circulation associated with January temperatures was found to be closely related to the December¹⁾NAO-like pattern and the predictors with the best predictive skills were identified to be the 500hPa geopotential height (Z500) anomalies averaged over the European and Lake Baikal regions in December.
 - When predictors' anomalies in both regions have negative values respectively, a pattern resembling the development of a negative NAO emerges, inducing negative Z500 anomalies in upper atmosphere over both regions through upper-level wave propagation.
 - The negative anomalies the upper atmosphere led to negative sea-level pressure anomalies, surface cooling, and increased snowfall in the Siberian region and subsequently, during early January, the development of the Siberian high pressure caused temperatures from the Lake Baikal area to the vicinity of the Korean Peninsula to drop below the climatological average.
 - It was analyzed that these predictors could be utilized specifically when below-normal temperatures are predicted in January. To be operationally applied for one-month lead prediction, the use of both observational and subseasonal prediction data was suggested.

1) NAO (North Atlantic Oscillation)

An atmospheric oscillation defined as the difference in atmospheric pressure between Iceland and the Azores.

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2) SVD (Singular Value Decomposition)

a multivariate statistical technique used widely in the atmospheric sciences to analyze interrelationship between two variables

3) MJO (Madden-Julien Oscillation):

Tropical oscillations in the lower atmosphere propagating from west to east on a 30-60 day timescale.

- The impact of Indian Ocean variability on January precipitation in Korea.
 - It was analyzed that the sea surface temperature (SST) of the South Indian Ocean (IO) in December can influence January precipitation in Korea and was suggested that this could be used as a predictor with a one-month lead time.
 - When SSTs in South IO rise in December, precipitation increases in the East IO leads to the development of high pressure in the upper atmosphere over the Arabian Sea, and subsequently, as waves propagate, high-pressure anomalies in lower atmosphere develop over East Asia.
 - South Korea tends to have increased precipitation in January due to the transport of warm and humid air by southerly wind anomalies located to the west of the high-pressure system.
- The impact of tropical Pacific convective activity in the autumn on mid-to-late winter temperatures in South Korea.
 - From the ²SVD analysis that was performed on the precipitation anomalies in the tropical Pacific Ocean in autumn and the winter temperature anomalies in Korea, a TSPM (Tropical South Pacific Mode) in autumn was defined as a predictor for the temperature in winter.
 - Convection suppression (enhancement) in the tropical Pacific in the autumn causes convection enhancement (suppression) in the central Pacific. This induces a low-pressure (high-pressure) anomaly, leading to suppressed (enhanced) convection in the northwest tropical Pacific.
 - Anomalous anticyclonic (cyclonic) circulation around the Korean Peninsula developing through upper-level wave propagation associated with convective activity in the northwest tropical Pacific induces warmer (colder) temperatures in South Korea.
 - Through the analysis of the relationship with the October ³MJO enhanced the utilization of TSPM predictors and the anomalous SSTs in the central Pacific Ocean in October were to be used to increase predictive skills in forecasting warmer-than-normal temperatures in winter.

B Analysis of climate change issues

- The future projection of sudden daily temperature drops (SDTD) during winter in South Korea.
 - Using high-resolution historical simulation data from three regional climate models, it was shown that the highest frequency of the SDTD events occurred in December, whereas the lowest frequency occurred in February.
 - In the future climate change scenario, the occurring frequency of SDTD events decreases in December and January, while the frequency increases in February.
 - One possible cause for the increased frequency of SDTD events in February in future climate change is the increased variability of the daily temperatures in February

C Improving Climate Analysis System (CAS)

- Improving CAS and expanding climate analysis services from CAS for enhancing user convenience
 - Observational data provided by NCEP and the KMA have been validated, and previously inconvenient climate monitoring and analysis services have been enhanced.
 - Data collection systems were standardized for timely response to extreme weather events.
 - To facilitate the timely delivery of climate monitoring information, features such as automated generation of predictive indicators, information provision systems, and time-series-based composite analysis tools have been developed.
 - For supporting seasonal forecasting discussions in APCC, the CAS automatically calculates relevant climate predictors and provides guidance on their utilization, leading to a significant improvement in work efficiency.

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Real-Time, Highly Validated Climate Prediction

3) Expected Effects

- Establishment of a foundation to lead the climate monitoring and analysis field in South Korea
- Strengthening of APCC's support functions for national climate prediction and analysis tasks
- Enhanced work efficiency through the establishment of the APCC climate monitoring and analysis system.
- Promoting APCC through appropriate responses to domestic issues and current challenges related to climate change.

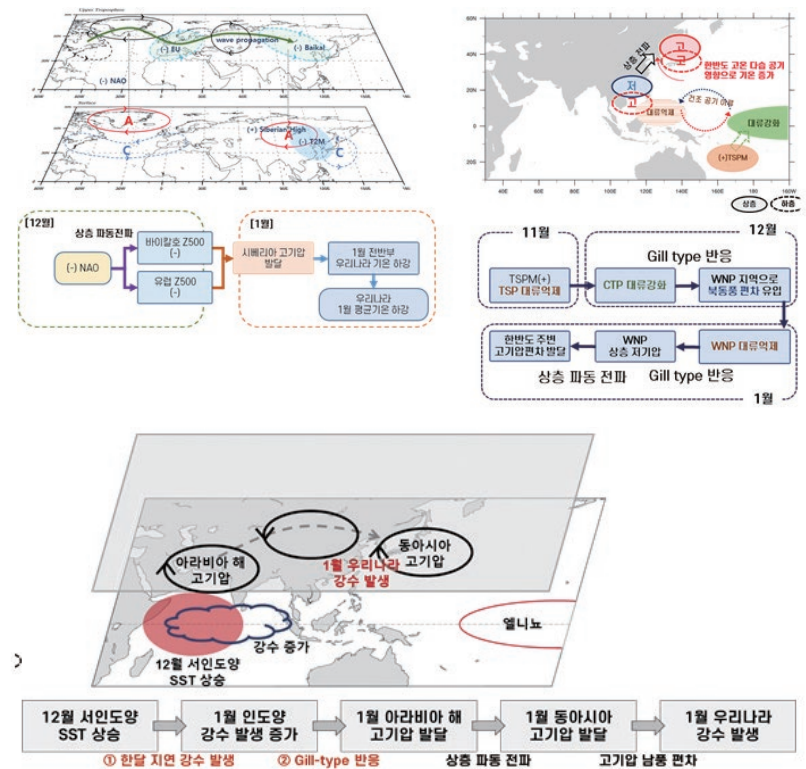


Fig. 22 Schematic for climate drivers affecting winter temperature and precipitation in South Korea: (upper left) Atlantic and mid-latitude wave propagation, (upper right) tropical Pacific convective activity, and (bottom) Indian Ocean variability.

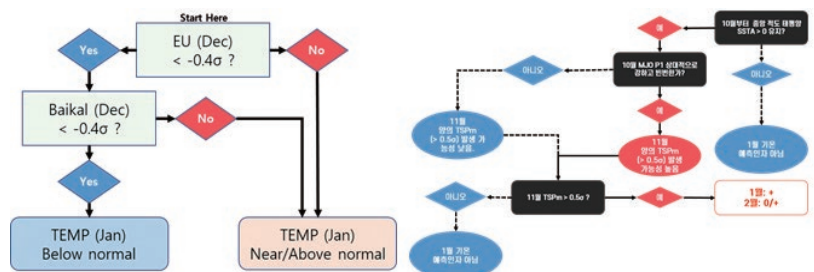


Fig. 23 Flowcharts for utilizing predictors related to (left) the Atlantic Ocean and mid-latitude wave propagation and (right) tropical Pacific convective activity in seasonal prediction of winter temperatures.

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Real-Time, Highly Validated Climate Prediction

1) Artificial Intelligence

The ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent agents (e.g., humans).

2) Subseasonal to seasonal (S2S) timescales

predictions of the time range between 2 weeks and 3 months

3) Feature Engineering:

The process of selecting, transforming, and creating features that enable the model to better understand the training data and represent the problem in order to improve the performance of a deep learning model.

4) GUI (Graphical User Interface)

A method of interaction with users that utilizes visual elements such as graphics, icons, buttons, windows, etc..

5) Semi-Supervised Learning

A machine learning technique that uses both labeled and unlabeled data to train a model

6) Deep Learning

A machine learning technique that teaches computers to do what comes naturally to humans

7) MJO RMM

the Real-time Multivariate MJO index and widely used for MJO monitoring. It is defined with the first two principal components of OLR (outgoing long-wave radiation) and zonal winds at 850- and 200-hPa.

1-3. ¹⁾Artificial Intelligence (AI)-based Objectification Technology Development for Climate Prediction

◎ Development of AI application technology suitable for climate prediction

Project 5

The Development Of Artificial-Intelligence-Based Technologies For Objective Climate Prediction (III)

- Dr. Seongkyu Lee geoslegend@apcc21.org

1) Background and Necessity

- Global companies and the ECMWF are developing and testing AI-based 14-day weather forecast models, but the application of AI to climate forecasting and the utilization of AI in practical work is still in its infancy.
- Research is needed to improve the predictability of ²⁾subseasonal to seasonal (S2S) timescales through development of AI-based climate prediction technologies for objective climate prediction.

2) Main Contents

A Expansion of AI Model Training Data and Advancement of Data Processing Systems

- Archive Training data for APCC seasonal/subseasonal climate prediction factors
- Integrate ³⁾feature engineering modules to data processing systems
- Enhancement of AI training data by user experience & interface ⁴⁾GUI

B Development of an enhanced subseasonal climate prediction AI model through expanded data integration and advanced preprocessing techniques

- Preprocessing, hyperparameter selection, and ensemble-based neural network model performance optimization

C Development of ⁵⁾semi-supervised deep learning model for probabilistic forecasting

- Improvement of ⁶⁾deep learning model for ⁷⁾MJO RMM prediction
- Understanding of deep learning model for MJO RMM prediction using ⁸⁾explainable artificial intelligence
- Evaluation of deep learning model for probabilistic MJO prediction

D Development of an artificial intelligence model for 5-6 week probabilistic temperature prediction in East Asia.

- Establishment of a foundation for the development and evaluation framework of a 5-6 week probabilistic temperature prediction model for East Asia, based on 3-4 week probabilistic temperature prediction models.
- Enhancement and evaluation of the 3-6 week probabilistic temperature prediction model through expansion of model input variables, modifications to deep learning model architectures, and improvements in deep learning training and prediction methods.
- Selection of the optimal deep learning model through evaluation of the 3-6 week probabilistic temperature prediction models.

E Development of deep learning models for post-processing seasonal time scale dynamical forecasts

- Developed three distinct AI-based techniques for post-processing 3-month averaged precipitation over East Asia: Ensemble SubSampling (SS), DeBiasing (DB), and Trans-

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Real-Time, Highly Validated Climate Prediction

fer-Learning based Diagnosing (TLD).

- Conducted a comprehensive performance evaluation of these AI-based post-processing techniques, comparing them with the conventional Quantile Mapping bias correction method.
- Proposed a new prototype for an AI-aided APCC Multi-Model Ensemble forecast by integrating outputs from the post-processing models.

F The improvement of climate predictions of summer/winter monthly mean temperature and the Standardized Precipitation Index for South Korea

- Built data-driven models based on 3D Convolution Neural Networks, and assessed the contribution of a data augmentation method, Cutmix, to the simple data-driven models
- Before-and-after analysis of semi-supervised learning for MJO phase classification model

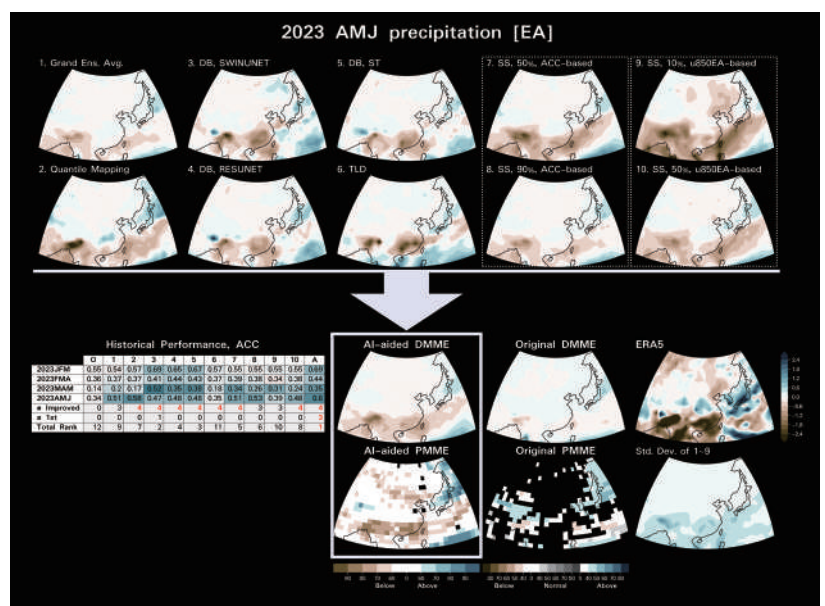


Fig. 24 A prototype of AI-enhanced multi-model ensemble forecasts for East Asia seasonal rainfall (e.g. AMJ, 2023)

8) eXplainable Artificial Intelligence

A set of processes and methods that allow human users to comprehend and trust the results and output created by machine learning algorithms

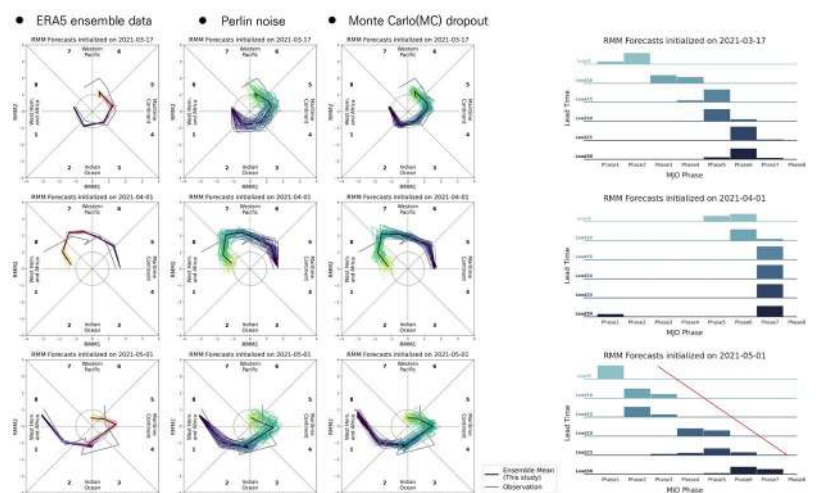


Fig. 25 Ensemble results of deep learning model for probabilistic MJO phase prediction for three MJO events. (Left) Phase diagrams of probabilistic MJO phase predictions for initial condition perturbation (ERA5 ensemble data and Perlin noise) and model weight perturbation methods (Monte Carlo dropout). (Right) Probability distribution of MJO phase predictions over lead times of 5, 10, 15, 20, 25, 30 days.

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Real-Time,
Highly Validated
Climate Prediction**1-4. Verification And Utilization System Improvement Of Climate Prediction Model**

- © Establishment of An Effective Improvement System for The National Climate Prediction Model

Project 6

Testbed construction And Development Of Its Utilization Technology For the National Climate Prediction Model

Dr. Sun-Hee Shin SSh222@apcc21.org

1) Background and Necessity

- Considering the limited human and computing resources in the domestic modeling community, strengthening our modeling capacity and continuously operating the testbed within the joint collaboration system ([K-R2O process](#)) are imperative to enhance the effectiveness of the climate prediction system.
- This aims to strengthen the Korean Meteorological Administration ([KMA](#)) Global Seasonal Forecast System version 6 ([GloSea6](#)) and includes three tasks:
 - i) the development of land-surface model improvement technology for KMA GloSea6,
 - ii) the evaluation of the possibility of applying the developed R&D technology to operations ([testbed](#)),
 - iii) the framework of verification system that suggests guidance for the models's improvement.

2) Main Contents**A Enhancement of Surface Processes to improve Predictive Skill in the KMA Climate Prediction Model (GloSea6)**

- Integration of Groundwater Algorithm into the JULES Land Surface Model
 - The GrUB groundwater algorithm was incorporated into the JULES land surface model, establishing the JULES-GrUB system
 - Comprehensive evaluations were conducted on hydrological and energy fluxes across seven major river basins
 - The integration of the GrUB algorithm overall enhanced predictive skill, particularly for latent heat flux and soil moisture, with pronounced improvements observed during the spring season
- Optimization of High-Resolution River Discharge Model ([TRIP](#)) and Operational Applications
 - Freshwater effects were analyzed using a high-resolution TRIP, demonstrating reduced errors in ocean circulation in the equatorial Pacific during summer and improved vertical profiles of ocean temperature, salinity, and sea surface temperatures near the Korean Peninsula
 - Optimization of river flow coefficients, including flow velocity and channel curvature, suggested potential enhancements in the simulation of ocean temperatures in the Indian Ocean
 - The operational applicability of the high-resolution river discharge model was confirmed through predictions skill evaluations using summer forecasts from 1995 to 2006

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Highly Validated
Climate Prediction**B Application and Validation of Joint Development Outcomes for KMA Climate Prediction Model**

- Implementation and Integration Testing of Advanced Model Physics
 - Conducted Unified Convection Scheme (¹⁾UNICON) experiments based on collaborative technology transfer between KMA and APCC
 - Performed integration experiments combining advanced sea ice physics with UNICON scheme
- Verification of Prediction Skill and Operational Applicability of Applied Technologies
 - Improvements in the simulation of mean monsoon climatology and interannual variability were limited, with notable regional biases in East Asian monsoon precipitation and amplified warm biases at high latitudes
 - Performance of teleconnection affecting East Asian summer climate showed minimal improvements in the UNICON experiment due to overestimation of rainfall over India and Southeast Asia
 - While GloSea6 effectively simulated heavy rainfall characteristics in June and July, the UNICON experiments underestimated water vapor, leading to weak cloud development
 - Suggestion for refining convective organization processes, addressing total moisture perturbations associated with cold pool advection, and optimizing computational efficiency for operational applications

C Extension and Advancement of Climate Prediction Model Evaluation and Management System (CrEMA)

- Extension of Diagnostic Framework for Arctic-Midlatitude and Tropical-Midlatitude Teleconnections
 - The CrEMA diagnostic framework was expanded to encompass Arctic Oscillation(AO)/ Sea Ice Concentration(SIC), East Asian Winter Monsoon(EASM), and Boreal Summer Intraseasonal Oscillation (BSISO).
 - Diagnostic metrics were developed for these phenomena, and an objective scorecard was introduced for systematic evaluation.
- Comprehensive Evaluation of Major Climate Variability in GloSea6 Using CrEMA
 - Arctic climate diagnostics revealed underrepresentation of troposphere-stratosphere interactions, including weakened polar vortex dynamics and downward wave propagation, associated with enhanced Eurasian snow cover during late autumn. Additionally, reductions in Barents-Kara sea ice were linked to inadequate simulations of surface heat flux and Arctic warming, impacting Arctic-midlatitude teleconnections.
 - Summer intraseasonal variability was underestimated, but improvements were observed in the northward propagation of BSISO due to enhancements in mean easterly wind shear over the Indian Ocean and northwestern Pacific eddy-related processes.
 - The predictability of interannual variability in the East Asian winter monsoon system elements has improved, but the improvement effect on remote correlation simulation performance is not significant due to the underestimation of continental high-pressure simulation performance and the underestimation of the interaction between the atmosphere and ocean in the western Pacific.

1) UNICON (United Convection scheme)

Process-based dynamic column model that incorporates vertical mixing in PBL and convection processes such as shallow and deep convection clouds

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Real-Time, Highly Validated Climate Prediction

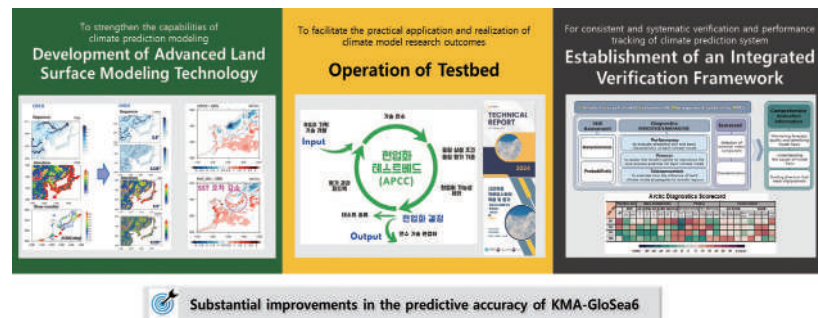


Fig. 26 A framework for developing model technology and diagnosing joint development technology to improve KMA Glosea6

3) Expected Effects

- Integrating JULES-GrUB and the high-resolution TRIP into KMA GloSea6 will enhance seasonal prediction performance by improving hydrological processes and atmosphere-ocean interactions.
- Through the testbed, we proposed the implementation of coupling optimization and sea ice physics optimization for KMA-GloSea6, which will contribute to enhancing the operational efficiency for improving climate prediction models.
- Through the CrEMA diagnostic system, integrated diagnostic information on key climate variabilities such as ENSO, MJO, and EASM in KMA-GloSea6 has been provided, which will be used to identify the model's weaknesses and improvement directions.

02 Green Climate Fund (GCF)- Supported Project

Since its establishment, the APEC Climate Center has been recognized by the international community for its climate-related expertise and knowledge gained through its climate information provision services in the Asia-Pacific region, and has been participating in the Green Climate Fund (GCF) support projects.

2-1. Project Initiated By The UN Environment Programme (UNEP)

Project 7. Enhancing Climate Information and Knowledge Services for resilience in five island countries of the Pacific Ocean

Dr. Jinho Yoo jhyoo@apcc21.org

1) Background and Necessity

- Pacific Island Countries (PICs) are among the most vulnerable nations to climate change and variability, yet their capacity for climate prediction is limited.
- APCC aims to enhance PICASO (Pacific Island Countries Advanced Seasonal Outlook), a tailored climate prediction tool developed for PICs, to help five Pacific countries respond more effectively to extreme climate events.
- In addition, APCC seeks to foster the climate prediction capacity of meteorological agencies in five PICs through continuous training programs.

2) Main Contents

A Improvement of prediction performance and enhancement of functions of the Pacific Climate Forecasting System (PICASO)

- Developing monthly temperature and precipitation prediction.
 - Selection of monthly temperature and precipitation prediction factors for the seasonal average and 1, 2, 3-month lead times for the five Pacific island countries has been completed.
- Improving the operational base system of PICASO
 - Improved the reliability of data transfer from APCC to the Pacific (single to dual path)
 - Enhanced the preprocessing efficiency of global model prediction data for PICASO production (reduced processing time from several days to a few hours)
 - Developed an Open API to enhance the usability of PICASO prediction information.
- Conducted field surveys and gathered relevant information for producing applied prediction data
 - Field surveys in Tuvalu, Marshall Islands, and Niue and selected target sectors for applied information

B Supporting Capacity Building in Climate Prediction for Pacific Island Countries

- Conducting one technical training and one APCC visit program
 - Young Scientist Support Program was held in May. 5 NHMS staffs from 5 countries

02 Green Climate Fund (GCF)- Supported Project

participated. Participants went through basic courses on the climate data analysis using python and finished individual research project on the impact of ENSO for each country.

- Joint regional training workshop was held in Tonga, October. 21 NHMS staffs from 14 countries participated. Lectures and hands-on sessions on the climate prediction by using the PICASO and climate analysis were provided.



Fig. 27 Young Scientist Support Program (May 2024, APCC)

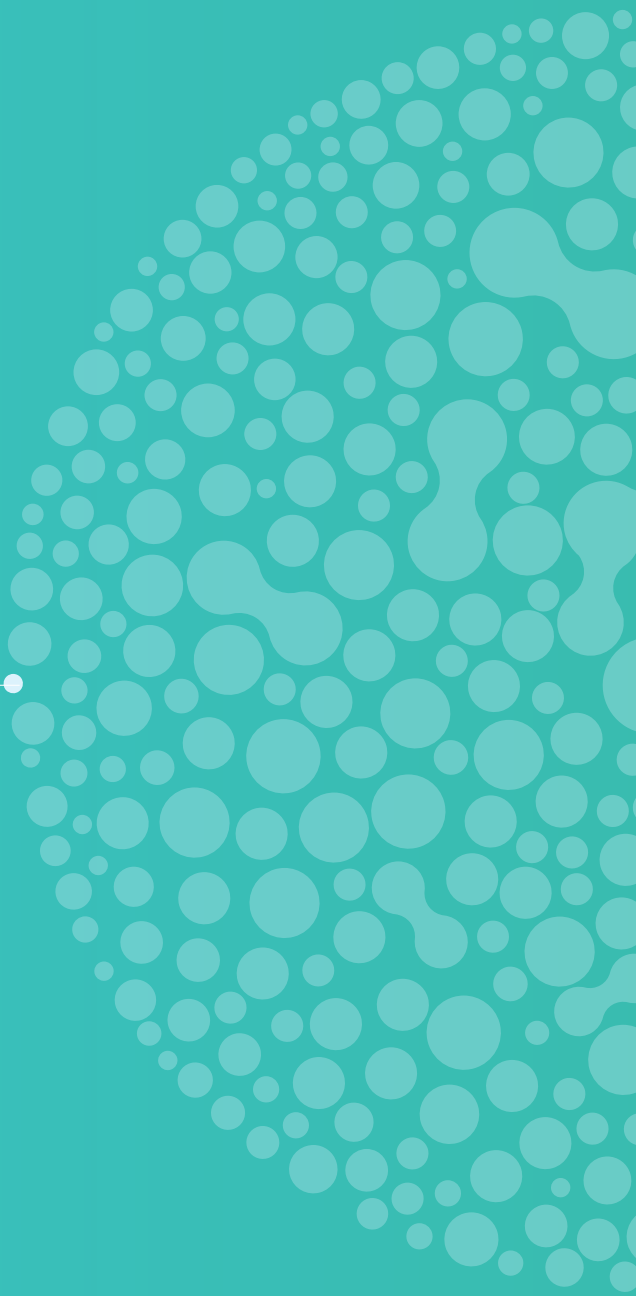


Fig. 28 Regional Training Workshop (Oct 2024, Tonga)

3) Expected Effects

- Improvement of national climate services through the enhancement of climate prediction capabilities and self-sufficiency in technology development in five Pacific island countries
- Expanding the usability of APCC's climate prediction information and enhancing its contribution to the Asia-Pacific region

APCC

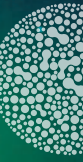


04

APEC Climate Center



APCC Introduction



APCC Introduction

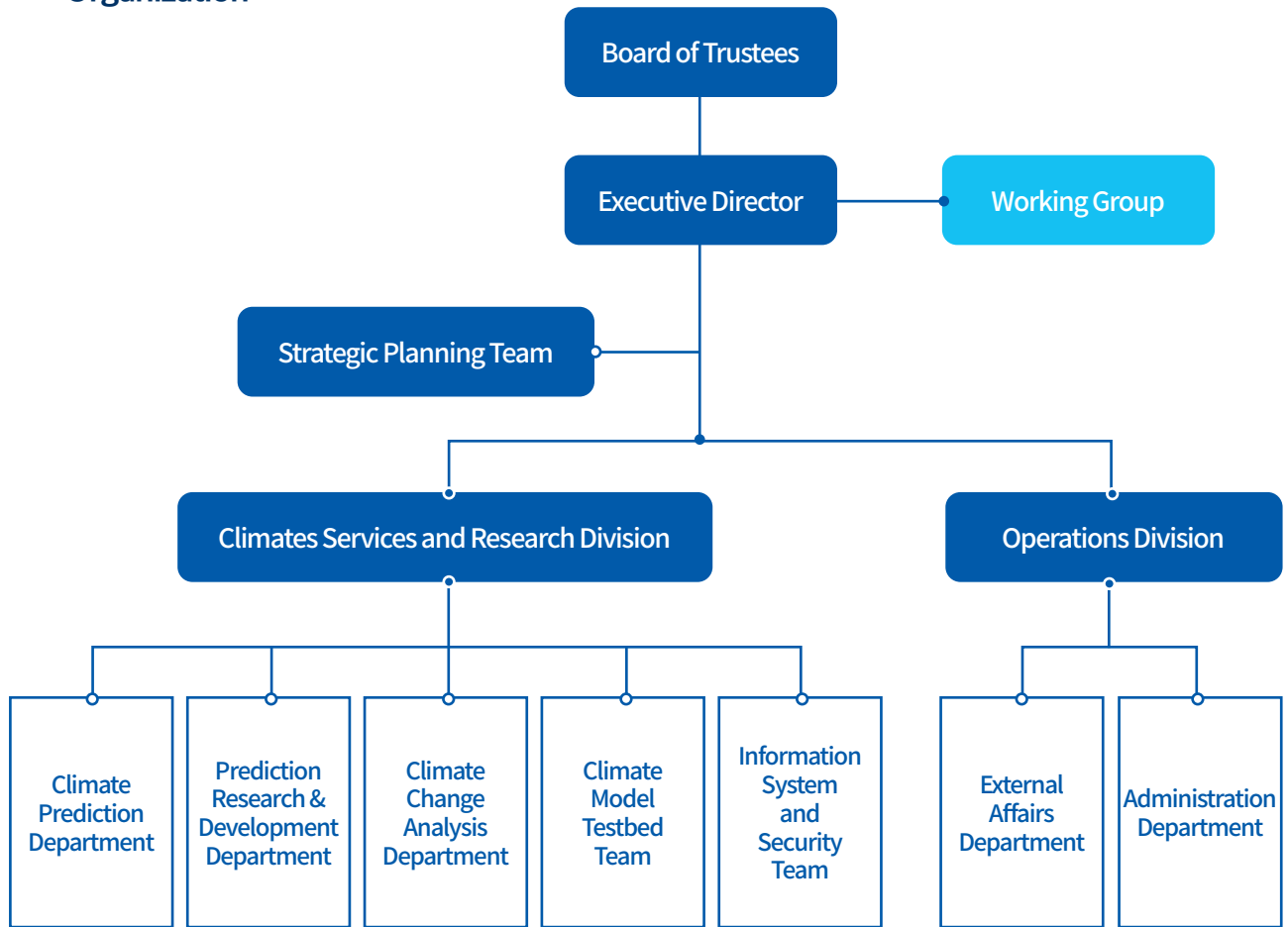
APCC



APEC Climate Center

APCC enhances the socio-economic well-being of its member economies by fostering cooperation in developing climate and climate change monitoring and prediction technologies, as well as promoting the effective use of related climate information.

Organization



Strategic Planning Team	Responsible for business planning and evaluation, as well as the management evaluation of public institutions, conducting ESG management initiatives, customer satisfaction and demand surveys, and implementing the Project Real-Name System for public institutions
Climate Prediction Department	Generating APCC MME and SCoPS seasonal predictions, producing and providing BSISO forecast information, operating the WMO Lead Center and ESGF, managing the APCC homepage, and supporting KMA's three-month outlook
Prediction Research & Development Department	Developing subseasonal prediction technology and systems, improving and advancing SCoPS, operating the SCoPS subseasonal prediction system, developing AI-based climate prediction technology, and supporting KMA's one-month outlook
Climate Change Analysis Department	Analyzing decadal-timescale variability, identifying the causes of climate change, assessing its impacts, and applying downscaling techniques to climate change scenarios, while also engaging in international cooperation with organizations such as the IPCC and UNFCCC
Climate Model Testbed Team	Responsible for evaluating climate prediction model improvement technologies based on testbeds, verifying climate prediction performance, and advancing the performance evaluation system for the KMA's climate prediction models
Information System and Security Team	Responsible for the operation and management of IT systems, networks, and information security, as well as providing support to users of these systems and networks.

05

APEC Climate Center



2024 News



APEC Climate Symposium 2024 held in Collaboration with APCC, SENAMHI, and APEC Peru



The APEC Climate Center (APCC), in partnership with the Peruvian National Service of Meteorological and Hydrological Service (SENAMHI) and APEC Peru, successfully hosted the APEC climate Symposium 2024. This year's symposium took place in Lima, Peru, from August 12 to 13, focusing on the severe impacts of El Niño-Southern Oscillation (ENSO) phenomena, represented by El Niño and La Niña, on the Asia-Pacific region. Discussions emphasized the necessity of strengthening collaboration among member economies to prepare for and respond to ENSO's challenges. A total of 120 participants from 16 economies attended the event.

ENSO, a recurring climate phenomenon driven by changes in sea surface temperature (SST) in the tropical Pacific ocean, significantly influences global weather patterns, including rainfall, storms, and temperature shifts across the Asia-Pacific region. With climate change intensifying extreme weather events, ENSO-related disruptions are increasingly impacting economies and livelihoods.

Under the theme of "Towards a Sustainable and Resilient Society through Enhanced ENSO Response and Preparedness," the symposium featured expert presentation on ENSO forecasting science and technology, sectoral impacts of ENSO and climate change, and strategies for collaboration. The event also included panel discussions for sharing experiences and policy recommendations on ENSO preparedness and response.

In the opening remarks, Do-Shick Shin, Executive Director of the APCC, emphasized that APEC member economies are experiencing direct and indirect impacts of extreme weather across sectors such as agriculture, public health, and water resource management. He stressed the importance of timely responses and science-based decision-making to minimize economic and social losses.

Peru's Vice Minister of Environment, Raquel Hillianova Soto Torres, noted the significant rise in annual disaster damages, which increased from USD 52 billion in the 1980s to USD 207 billion in the last decade, and further to USD 232 billion in the first three years of the 2020s. She highlighted the critical role of climate science and technology in disaster risk management and enhancing resilience.

Carlos Vasquez, Chair of APEC Senior Officials' Meeting, underscored ENSO's profound impacts on the Asia-Pacific region and reiterated APEC's longstanding recognition of the urgency of addressing climate change through collective action among member economies.

01_

During keynote speech, Prof. Shang-Ping Xie from the University of California San Diego, explained how global warming is amplifying El Niño's effects, leading to increased storm activities and heavy rainfall. He also pointed out the potential for long-term warming trends to moderate ENSO intensity. Prof. Xie stressed the importance of improving observational data, advancing climate models, and conducting in-depth research on ocean-atmosphere interactions to enhance ENSO prediction and response capabilities.

Following the keynote speech, the symposium featured three thematic sessions: i) current status of ENSO science and technology, ii) impacts of ENSO on agriculture, water resources, and public health and collaborative response strategies, and iii) multi-stakeholder approaches to addressing ENSO and climate change.

Each session included experts presentations and discussions, highlighting the latest scientific advancements, case studies of regional cooperation, and actionable strategies for building resilience to ENSO impacts.

For more detailed information about the presentations and discussions at the APEC Climate Symposium 2024, please visit the APEC Climate Center website.

The APCC aims to maximize the utilization of climate information through the annual symposium and strengthen the global network of experts and organizations addressing climate change, particularly in the Asia-Pacific region. Given that the symposium is hosted in collaboration with the APEC host economy each year, the event incorporates APEC's priority areas and themes. In 2024, the symposium focused on ENSO, aligned with Peru's priorities as the APEC host economy. Looking ahead, as South Korea takes on the role of APEC host economy in 2025, the symposium's theme will reflect Korea's theme and key priorities.

APCC

02 _

APCC and NIMS cohosted 2024 APCC CPW from July 4-5, 2024



The APEC Climate Center (APCC), in collaboration with the National Institute of Meteorological Sciences (NIMS), successfully hosted the 5th APCC Climate Prediction Workshop on July 4–5 in 2024, at the auditorium of the Korea Meteorological Administration in Seoul. The theme of the workshop was “Technological Advancements and Cooperation for Future Projections in the Era of Climate Crisis.”

Since 2020, APCC has been organizing the Climate Prediction Workshop annually to advance domestic climate prediction technologies, foster impactful outcomes, and strengthen professional expertise and collaboration among climate prediction researchers. The 5th workshop in 2024 aimed to address the intensifying climate crisis by enhancing the expertise and synergy between APCC and NIMS, contributing to scientifically informed national responses to climate challenges.

Under the overarching theme of technological advancements and cooperation to tackle the climate crisis, the workshop featured expert presentations on subseasonal-seasonal-decadal predictions, future climate projections, and sector-specific responses to climate change impacts. Additionally, in-depth panel discussions were held to explore collaborative strategies for technological advancements across various sectors.

The workshop facilitated insightful discussions among experts on identifying appropriate research directions and effective methods for communicating information in rapidly changing climatic conditions. Key topics included potential collaborations for technological development across institutions and industries, as well as the evolving role of climate information providers in addressing the climate crisis. The materials presented and discussed during the workshop are available through the APCC website.

Through its annual Climate Prediction Workshop, APCC continues to provide a platform for experts from diverse fields to engage in vibrant discussions on climate-related topics. This initiative supports the advancement of national climate prediction technologies, and APCC anticipates further meaningful contributions from these exchanges in the years to come.

03 _

The APEC Climate Center Attended the 7th Pacific Meteorological Council to Address Climate Change at the Pacific Islands Countries



A delegation from the APEC Climate Center (APCC), including APCC Executive Director Do-Shick Shin and Dr. Jong Ahn Chun, Research Fellow, attended the 7th Pacific Meteorological Council (PMC), held in Vanuatu, one of the Pacific Island nations, from September 17 to September 19, 2024.

During this visit, the APCC delegation conducted the climate cooperation meetings with high-ranking ministers from the South Pacific Regional Environment Program (SPREP) and Pacific Island Countries, focusing on climate and climate change. Additionally, on Tuesday, September 17, 2024, they hosted a PMC side event.

At the side event, they presented the Pacific Island Countries with the successful development case of the Van-KIRAP tailored System of Climate Services for Agriculture (OSCAR) for Vanuatu's agricultural sector and achievements in building a sustainable operation and maintenance system of OSCAR. They also strengthened their climate cooperation network with local governments.

APCC

04 _

APCC Discusses Expanding Climate Information Services and International Collaboration for Pacific Island Countries at COP29



The APEC Climate Center (APCC) participated in the 29th UN Climate Change Conference of the Parties (COP29) in Baku, Azerbaijan, from November 15 to 23, 2024. The delegation highlighted the achievements of the Van-KIRAP project, particularly the OSCAR system, which supports climate risk management and agricultural productivity through innovative climate information services. Successfully transferred to the Vanuatu government in 2023, OSCAR has become a model for sustainable climate adaptation in the Pacific. A side event showcased its successes and explored expansion strategies to other regions.

APCC engaged with international stakeholders, including SPREP, VMGD, and WMO, to discuss the Van-KIRAP-II project and the broader scalability of climate information systems. This collaboration reinforced APCC's leadership in climate resilience and laid the groundwork for extending tailored climate services globally. Future efforts will focus on developing region-specific adaptation projects to enhance resilience against climate change.

APCC

05 _

APCC Completed a Young Scientist Support Program 2024



The APEC Climate Center (APCC) held a Young Scientist Support Program 2024 (YSSP 2024) from May 30, 2024, to June 28, 2024 (30 days) by inviting 5 YSSP 2024 participants from 5 Small Island Developing States in the Pacific to Haeundae, Pusan Metropolitan City.

APCC is currently participating as a technical partner in the programme “Enhancing Climate Information and Knowledge Services for Resilience in 5 island countries of the Pacific Ocean (hereafter UNEP CIS-Pac5)”, initiated by the UN Environment Programme (UNEP). The 5 Small Island Developing States (SIDS) in the Pacific are the Cook Islands, Niue, Palau, the Republic of the Marshall Islands (RMI), and Tuvalu.

The training is being organized under the UNEP CIS Pac5 project (GCF FP147), with the overarching goal of strengthening technical capacity for increased consideration and use of research and other evidence in decision making, so as to support facilitating the integration of climate change adaptation into long term strategies.

Through this comprehensive and action oriented program, APCC will be training participants on how to access, collect, and process climate data, for a better understanding of the impacts of climate. Participants gained knowledges and skills on climate data analysis using Python script. Based on the new skill, they analyzed the impact of ENSO on each country's rainfall variability and its diversity.

06 _

APCC, UNEP, SPREP and WMO Co-hosted the 3rd Joint Regional Training Workshop on Enhancing Climate Information Services for Resilience in 5 Island Countries of the Pacific Ocean



The APEC Climate Center (APCC), the United Nations Environment Programme (UNEP), the Environment Program (SPREP) and the World Meteorological Organization (WMO) co-hosted 'the 3rd Joint Regional Training Workshop on Climate Prediction and PICASO' between 14th and 18th October 2024 in Nukualofa, the Kingdom of Tonga.

This regional training workshop was held as part of the transformative programme, "Enhancing Climate Information and Knowledge Services for resilience in 5 island countries of the Pacific Ocean", initiated by the UN Environment Programme (UNEP). APCC is participating in this programme as a technical partner.

During this joint regional training workshop, APCC researchers conducted the lectures on climate prediction and implemented training programs on the utilization of the Pacific Island Countries Advanced Seasonal Outlook (PICASO) system as well as the production methods of seasonal outlook. The hands-on sessions on the relationship between local climate and large scale variability were provided to improve knowledge on the climate variability and predictability of the participants.

By so doing, APCC and UNEP promote to upgrade the enhancement of the climate prediction and climate information utilization capabilities of the meteorological offices of the five Pacific island countries. It is expected to enhance the resilience capacity of these regions against climate change.

07 _

APCC Promotes Collaboration with the SENAMHI (Servicio Nacional de Meteorología e Hidrología del Perú) to Enhance Climate Information Services for Strengthening Climate Resilience in Peru



The APEC Climate Center (APCC), in collaboration with Weatherpia Co., Ltd. and external experts has initiated the project “Strengthening Climate Resilience in Peru through Enhanced Climate Information Services and Capacity building for Climate Change Monitoring and Prediction” supported by the Korea International Cooperation Agency (KOICA) from October 2024. The project is scheduled to conclude in May 2025.

This initiative, carried out with the active cooperation of the SENAMHI, aims to ensure the effective utilization of SENAMHI's climate information to enhance the capacity of various regions in Peru to respond proactively to extreme climate events. To achieve this, a couple of on-site survey was conducted in October and November in 2024. These surveys involved in-depth interviews with diverse stakeholders, including government ministries, related organizations, local producers, and NGOs, to analyze local needs, capacity and the circumstances.

Based on the interviews and demand assessments, the team shared preliminary findings with stakeholders at a workshop held on November 29, 2024, at the Auditorium in the Ministry of Agriculture and Irrigation of Peru (MIDAGRI). More than 60 participants, including representatives from SENAMHI, the Ministry of Agriculture and Irrigation, the Ministry of Environment, and other partner organizations and stakeholders participated in this workshop. Attendees collectively acknowledged the importance of climate information services and the necessity for multifaceted and continuous cooperation.

Eng. Gabriela Rosas Benancio, Executive President of SENAMHI, expressed her hopes that collaboration with international partners such as APCC would lead to the provision of high-quality climate services to vulnerable sectors, thereby strengthening national climate resilience. She also voiced her support and expectations for continued collaboration.

Through this project, the team plans to develop a medium- to long-term roadmap to en-

07 _

hance Peru's climate resilience. They will also propose priority follow-up initiatives ([Track 2 project in KOICA](#)) to achieve these goals. Using insights from the field surveys, the project aims to support the activation and expansion of SENAMHI's Agricultural Climate Management Platform ([PGA](#)) and enhance the technical capabilities for climate prediction and data analysis, enabling the implementation of more effective climate information services.

The project will be further refined through the third on-site visit scheduled for February 2025.



08 _

APCC Website Renewal to Increase Ease of Use and Usability of Climate Information Services

The APEC Climate Center (APCC) has reorganized its official website (<https://www.apcc21.org>) using dynamic web technology to improve the ease of use and usability of climate information services.

The newly revamped APCC website uses dynamic web technology to provide actual figures and additional information when users select an area of interest in the image with the mouse. On the other hand, on the previous website, information users estimated the values of the region of interest by referring to the legend of the fixed image of the climate information.

In addition, its official website reorganization enabled us to supplement the content of the previous website, increase the visibility of the design, and provide an optimized screen tailored to various digital environments.



09 _

APCC hosted the 2024 APCC Climate Information Service User Workshop

The 2024 Climate Information Service User Workshop was held on 26-27 September 2024. APCC has been hosting this workshop since 2017 to expand the usability of climate information services produced and provided by APCC and to deliver services that meet user needs. The workshop was attended by five participants, including representatives from domestic climate and environmental organizations as well as university and graduate school students, majoring in climate-related subjects.

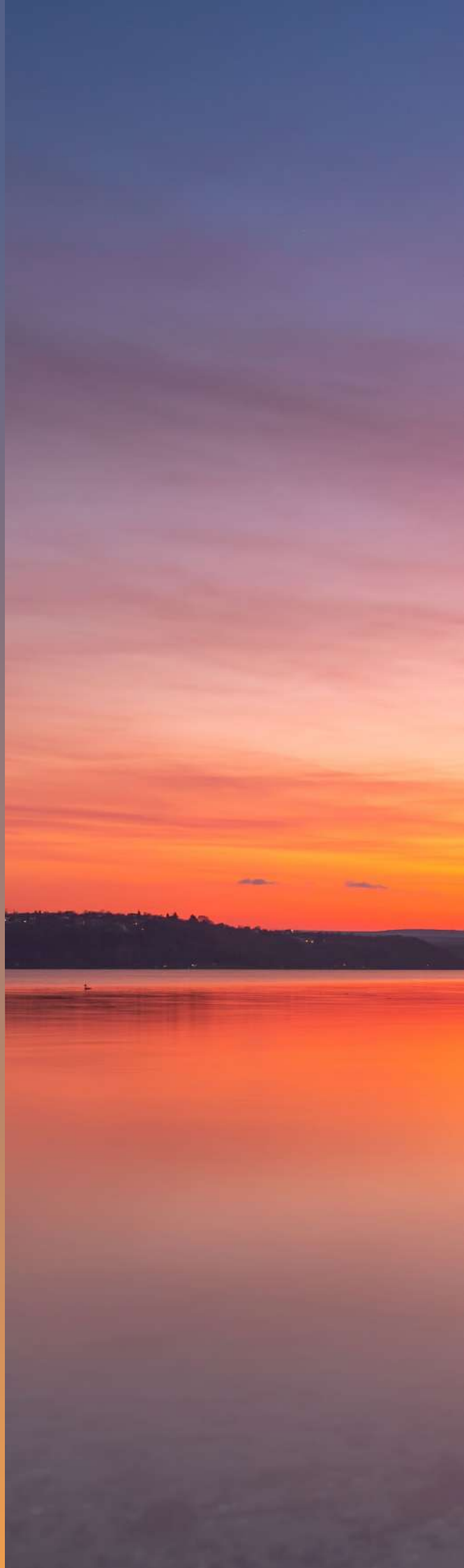
Sessions covered a variety of topics, assessing the impacts of climate change, producing and utilizing predictions of intraseasonal oscillations for summer, and climate monitoring and analysis. The program also included a comprehensive hands-on session on the APCC Climate Information Service Integrated Platform (CLIK).

APCC plans to continue offering such user-participatory programs to secure new users and provide services that address user needs through education on climate prediction and climate information service applications.

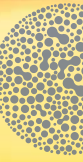


06

APEC Climate Center



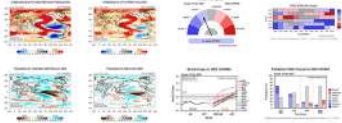
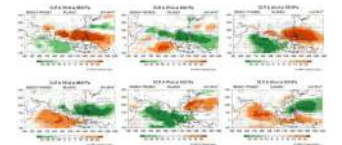
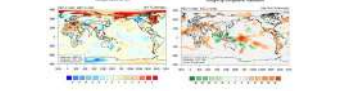
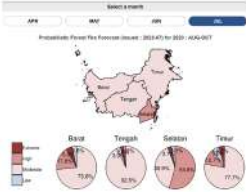
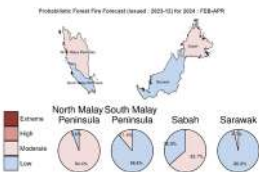
APPENDIX



APPENDIX 1.

APCC Climate Information Services

APCC (www.apcc21.org) provides climate information services to end-users around the world. .

Classification	Service Name	Service Screen	Description
Provision of Climate Information	Seasonal Forecast (Climate forecast for 3 or 6 months)		- APCC provides high quality 6-month climate outlooks, updated monthly, for APEC member economies and climate-related agencies around the world. https://apcc21.org/ser/global/outlookSummary.do?lang=ko
	BSISO (Boreal Summer Intraseasonal Oscillation) Forecast		- The BSISO is the one of the dominant phenomena over the Asian summer monsoon region. The BSISO monitoring index for 15 to 60 days is provided through APCC homepage in real time. https://apcc21.org/ser/meth.do?lang=ko
	Climate Monitoring		- APCC presents information on major climate variables, including droughts, floods, and atmospheric circulation, that can greatly affect people's daily lives on a weekly, monthly, and seasonal basis. https://apcc21.org/ser/high.do?lang=ko
Customized Climate Information Service	APCC Climate Services Platform CLIK, CLimate Information toolKit, https://cliiks.apcc21.org	Provision 	APCC Climate Services Platform enabling us to provide climate information services by which users can effectively utilize various climate data Provision Service : A platform-based climate data service that allows to download APCC climate information in various formats. Production Service : a service that enables users to select climate models, variables of prediction, regions, and analysis techniques online to produce MME climate prediction information and statistically downscaled information for desired areas. Processing Service : a service enabling to extract the values of climate variables in user's desired areas or periods from a large amount of climate data in a variety of data formats
		Production 	
		Processing 	
Use of Climate Information	SEA Fire and Haze Early Warning System (FHEWS) – Indonesia		APCC presents its developed fire and haze EWS, which translates 6-month precipitation data into four fire danger ratings based on the relationship between the precipitation amount and CO2 emissions. This data will be utilized to prevent dangerous forest fires and haze. 1. Indonesia: https://www.apcc21.org/prediction/fhewsid 2. Malaysia: https://www.apcc21.org/prediction/fhewsmys
	SEA Fire and Haze Early Warning System (FHEWS) – Malaysia		

APPENDIX 2.

APCC Multi-Model Ensemble Participating Model

The APEC Climate Center (APCC) disseminates high-quality climate forecast information based on the multi-model ensemble (MME) on the 15th of every month. Currently, 16 operational institutes from 11 countries participate in the APCC MME. Real-time forecasts by APCC MME is provided on the APCC homepage every month (<https://www.apcc21.org>).

Improvements in the APCC MME Prediction and Monitoring Information

APCC redesigned its Seasonal Climate Outlook which provides more improved structure and format for users to better understand the contents. The prominent change is applied in the structure of the outlook; while the previous outlook provided text descriptions and images separately, in the new version of APCC climate outlook, images and text descriptions are put together in parallel in order for users to read and understand the contents without any interruptions such as turning pages. Especially, this revamp focused on the better readability and visibility of descriptions on the MME probabilistic forecast. The colors of temperature and precipitation probability categories are reflected in the texts as well as image of climate forecasts so that the users can easily distinguish different probabilities and impacts in the affected areas. The first renewed outlook has been rolled out on the November 15, 2023.

APCC opened the renewed APCC website from February 2024. All web pages will be refreshed using the latest web service technology and new design. We will also apply dynamic web contents for MME and individual model forecasts, climate monitoring, and climate indices.

Improvement of Participating Models of APCC MME

In 2024, two models from ¹⁾ECCC, ²⁾MGO were upgraded. These models were successfully applied to MME after some evaluation and enhanced the MME's forecast performance.



1) ECCC (Environment and Climate Change Canada)

Environment and Climate Change Canada

2) MGO (Voeikov Main Geophysical Observatory)

Voeikov Main Geophysical Observatory

APPENDIX 3.

Boreal Summer
IntraSeasonal
Oscillation (BSISO)

APCC produces Boreal Summer IntraSeasonal Oscillation (BSISO) monitoring and forecast information every day from May to October. BSISO represents a large circulation system, generated in the tropical Indian Ocean, with prominent gradual northward propagation. It affects the Asian summer monsoon, atmospheric circulation, and weather and has a 15-60 day period. BSISO consists of two modes: BSISO1 represents the canonical northward propagating variability with a 30-60 day period, and BSISO2 corresponds to the northward/northwest propagating variability, with a period of 10-30 days. Each BSISO is represented as eight phases with primary convection cell location. Currently, APCC operates BSISO with five models from four institutes (¹NCEP, ²ECMWF, ³CWA, and ⁴BOM).

In 2022 APCC changed the climatological base period from 1981-2010 to 1991-2020 for all BSISO contents, including monitoring, forecast and impact fields to follow the WMO recommendation to use the most-recent 30-year period as the climatological standard normal. The graphics on the BSISO website were also reformatted to increase readability and visibility.

In 2023, APCC started to provide BSISO impact anomaly up to four weeks and expand its area to 50 degrees of north with the expectation that this information will help users who need medium-range forecast in the Asian monsoon region.

The NOAA un-interpolated OLR (Outgoing Longwave Radiation) data, which was input data of the APCC BSISO monitoring index, has been no longer provided since September 17, 2023. Therefore, the OLR input data has been changed to NOAA CPC blended data, and the BSISO service has commenced from May 2024.

1) NCEP (National Centers for
Environmental Prediction)

National Centers for Environmental
Prediction

2) ECMWF (European Centre for
Medium-Range Weather Forecasts)

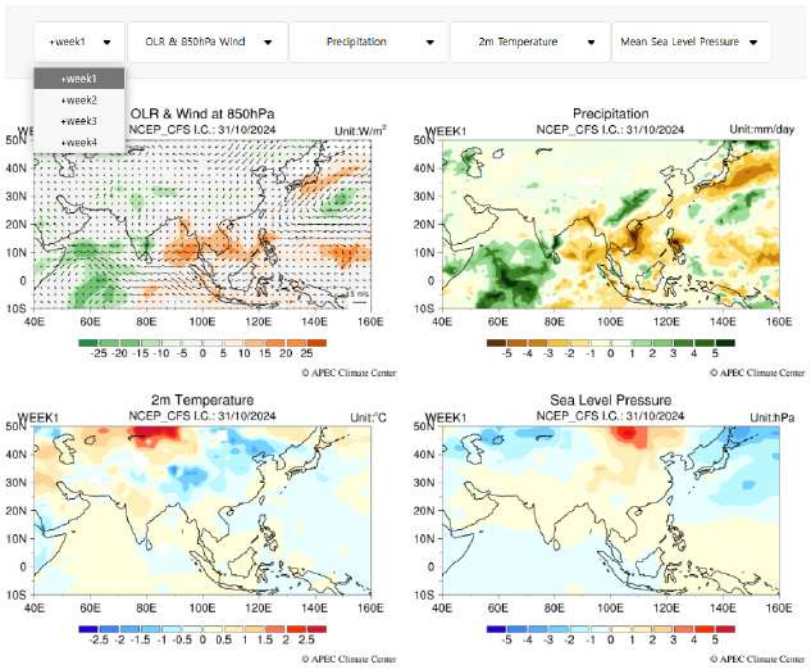
European Centre for Medium-Range
Weather Forecasts

3) CWA (Central Weather
Administration)

Central Weather Administration

4) BOM (Bureau of Meteorology)

Bureau of Meteorology



Example of APCC BSISO forecast impact anomaly on the website

APPENDIX 4.

Research Papers

1. **Suryun Ham, Yeomin Jeong, Jin Ho Yoo, Somin Lim, Heesook Ji & Yu-Kyung Hyun**, 30 OCT. 2023 : What is the effect of atmospheric initial condition inconsistency between the hindcasts and real-time forecasts?, *Climate Dynamics* Volume 62, pages 1613-1623, 2024)
<https://doi.org/10.1007/s00382-023-06972-8>
2. **Young-Mi Min, Chang-Mook Im, Vladimir N. Kryjov, Daeun Jeong**, 30 Mar. 2024 : Recent Challenges in the APCC Multi-Model Ensemble Seasonal Prediction: Hind-cast Period Issue, *JGR Atmospheres* Volume 129, Issue 7
<https://doi.org/10.1029/2023JD039787>
3. **Matthew C. Wheeler, Hanh Nguyen, Chris Lucas, Zhi-Weng Chua, Simon Grainger, David A. Jones, Michelle L. L'Heureux, Ben Noll, Tristan Meyers, Nicolas C. Fauchereau, Alexandre Peltier, Thea Turkington, Hyung-Jin Kim, and Takafumi Umeda**, 25 Jun 2024 : Making Progress on the Operational Alerting of El Niño and La Niña in a Warming World, *Bulletin of the American Meteorological Society* Volume 105: Issue 6, E1042–E1044
<https://doi.org/10.1175/BAMS-D-24-0095.1>
4. **Gaeun Kim, Woo - Seop Lee, Baek - Min Kim**, 20 May 2024 : Can seasonal prediction models capture the Arctic mid-latitude teleconnection on monthly time scales?, *Atmospheric Science Letters* Volume 25 Issue 8, e1235,
<https://doi.org/10.1002/asl.1235>
5. **Uran Chung, Jinyoung Rhee, Miae Kim, Soo - Jin Sohn**, 30 Aug. 2024 : Advancing sub-seasonal to seasonal multi-model ensemble precipitation prediction in east asia: Deep learning-based post-processing for improved accuracy, *Heliyon* Volume 10 Issue 16, e35933,
<https://doi.org/10.1016/j.heliyon.2024.e35933>
6. **Sinil Yang, DW Shin, Steven Cocke, Chaehyeon Chelsea Nam, Mark Bourassa, Dong-Hyun Cha and Baek-Min Kim**, 14 Oct. 2024 : Unveiling the pivotal influence of sea spray heat fluxes on hurricane rapid intensification, *Environmental Research Letters*, Volume 19, Number 11,
<https://doi.org/10.1088/1748-9326/ad7ee0>
7. **Soo-Jin Sohn, Hae-Jeong Kim, Sun-hee Shin, Jin Ho Yoo, Johan Lee, Kyung-On Boo, and Yu-Kyung Hyun**, 11 Oct. 2024 : Sharing Small Resources and Making Joint Efforts for the Improvement of Climate Prediction Model in South Korea, *Bulletin of the American Meteorological Society* ([Online Publication](#))
<https://doi.org/10.1175/bams-d-23-0150.1>
8. **Yu-Kyung Hyun, Jinkyung Park, Hee-Sook Ji, Johan Lee, Beomcheol Shin, Sang-Min Lee, Lee, Hyun-Ju, Hyung-Jin Kim, Yeon-Hee Park, Ji-Yeong Kim, Kyung-On Boo**, 27 Oct. 2024 : Comparative Assessment of the Seasonal Prediction Skill of Climate Prediction Systems ([GloSea6](#)) Using WMO LC-LRF Verification, *Atmosphere. Korean Meteorological Society*, vol.34, no.4, pp. 463-480 ([18 pages](#))
<https://doi.org/10.14191/Atmos.2024.34.4.463>



APEC CLIMATE CENTER

2024 Annual Report

We would like to express our gratitude to all staff and international partners who have contributed to the preparation of this publication.

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