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RESEARCH NEWS STORY

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From Drops to Data: Advancing Global Precipitation Estimates with the LETKF Algorithm

Researchers propose a new data assimilation algorithm to improve precipitation predictions worldwide

Estimating global precipitation is vital for managing water-related disasters, yet it is often challenging due to sparse rain gauge data in certain areas. To improve these predictions, Assistant Professor Yuka Muto and Professor Shunji Kotsuki, a research duo from Chiba University, developed a new tool using the Local Ensemble Transform Kalman Filter technique for rain gauge observations and reanalysis precipitation. Their method offers promising results for improving disaster management and sustainable water supply strategies.

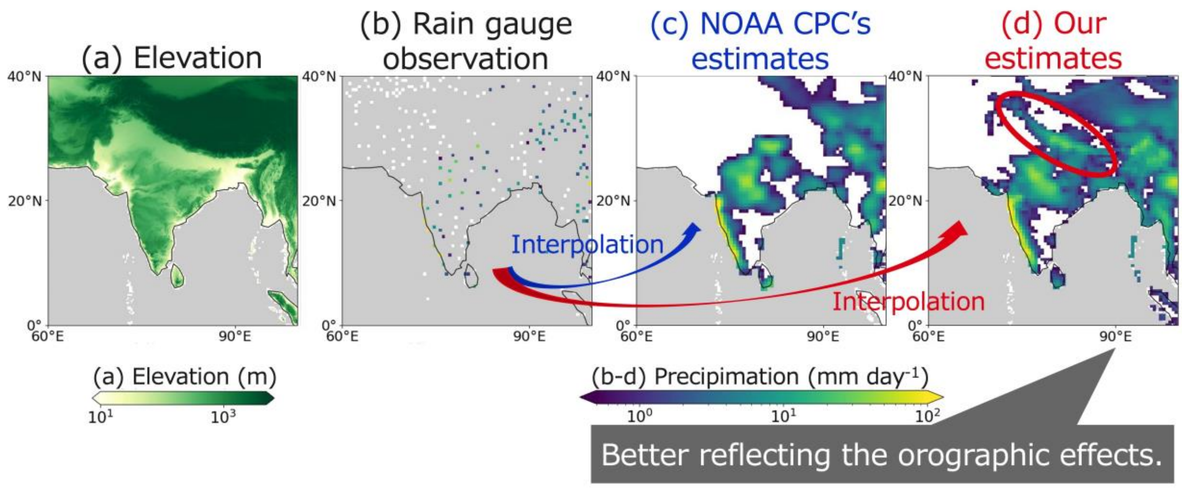

Image title: NOAA CPC precipitation estimates versus precipitation estimated by the newly proposed method
Image caption: (a) The elevation (m) and examples of (b) the rain gauge observation inputs and the global precipitation estimates of (c) the National Oceanic and Atmospheric Administration Climate Prediction Center (NOAA CPC), and (d) our study.
Image credit & source link: YUKA MUTO from Chiba University (https://doi.org/10.5194/hess-28-5401-2024)
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With the increase in climate change, global precipitation estimates have become a necessity for predicting water-related disasters like floods and droughts, as well as for managing water resources. The most accurate data that can be used for these predictions are ground rain gauge observations, but it is often challenging due to limited locations and sparse rain gauge data. To solve this problem, Assistant Professor Yuka Muto from the Center for Environmental Remote Sensing, Japan, and Professor Shunji Kotsuki of the Institute for Advanced Academic Research, Center for Environmental Remote Sensing, as well as the Research Institute of Disaster Medicine of Chiba University, Japan, have created a state-of-the-art method using the Local Ensemble Transform Kalman Filter (LETKF) technique. This study was published in Volume 28, Issue 24 of *Hydrology and Earth System Sciences* on December 17, 2024.

LETKF is a sophisticated data assimilation algorithm that makes global precipitation fields more accurate and is used in meteorology, oceanography, and environmental science. It combines real-world observations with computer model simulations to provide accurate, real-time predictions of complex systems. When combined with different inputs, like sensors, satellites, and ground stations, it can provide more precise predictions, minimizing errors. In this study, Dr. Muto and Professor Kotsuki used the LETKF to enhance the ground data estimates through reanalysis. "*We aimed to enhance the global precipitation estimates by integrating reliable ground rain gauge observations with dynamically consistent data from reanalysis precipitation*," explains Dr. Muto when talking to us about the rationale behind this study. Adding further, she says, "*We observed that the LETKF algorithm not only improves the accuracy of the precipitation estimates, but it also offers computational efficiency, making it a reliable solution for large-scale applications.*"

To begin with, the team required two sets of inputs: the actual rain gauge observation data and the reanalysis data. For this, they utilized rain gauge observations acquired from the National Oceanic and Atmospheric Administration Climate Prediction Center (NOAA CPC). They further incorporated the reanalysis precipitation data from the European Centre for Medium-Range Weather Forecasts (ERA5), which is a fifth-generation atmospheric reanalysis dataset produced by the ERA5 using satellite inputs and numerical weather prediction models. By using a 20-year climatological dataset from the ERA5 data (for 10 years before and 10 years after a given date), the LETKF algorithm constructed a "first guess" for the precipitation field and its error covariance. Further, the rain gauge observations from NOAA CPC were integrated into these first-guess ERA5-based precipitation fields by using the LETKF. The model enabled precise interpolation, even for regions that have sparse observational coverage.

Explaining the efficiency of this method, Professor Kotsuki adds, "*Our estimates showed better agreement with independent rain gauge observations and were more reliable even in mountainous or rain-gauge-sparse regions when compared to the existing NOAA CPC product*." The model showed significant improvements in capturing the precipitation patterns in areas including the Himalayas, the Andes, and the central region of Africa. This reliability could hold a high potential in addressing natural disasters and resource allocations.

The proposed methodology is more reliable than conventional techniques due to its ability to construct a physically consistent first-guess estimate by using reanalysis data. In this, the model preserves the critical variations in precipitation patterns while reducing the smoothing effects that are often observed in existing models. This dynamic consistency is especially beneficial for complex terrains, like mountains, where conventional methods struggle.

Reflecting on the long-term implications of the study, Dr. Muto adds, "*We believe that accurate precipitation estimates can transform how we prepare for and respond to disasters. By reducing uncertainty, we can mitigate economic losses, support sustainable water management, and prevent the stagnation of economic activities caused by extreme weather events.*"

In summary, this study holds the potential to drive international collaborations and also innovations in climate science to ensure that global water resources are managed well to meet the challenges of the changing climate.

About Assistant Professor Yuka Muto from Chiba University

Yuka Muto is an Assistant Professor at the Center for Environmental Remote Sensing at Chiba University, Japan. She earned her Ph.D. in Engineering from the University of Tokyo, Japan, in March 2022. Her research focuses on the global water cycle, particularly on enhancing precipitation estimation through data assimilation techniques. She has over nine publications to her credit and has developed methodologies that integrate various observations, such as rain gauges and satellite measurements, to improve the accuracy of global precipitation estimates.

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Reference:

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