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Editorial

Emerging Hydro-Climatic Patterns, Teleconnections, and Extreme Events in Changing World at Different Timescales

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The *Atmosphere* Special Issue, entitled "Emerging Hydro-Climatic Patterns, Teleconnections and Extreme Events in Changing World at Different Timescales", comprises thirteen original papers.

Climate is a complex system regulated by interactions among components of Earth at different spatial and temporal scales. Unravelling spatiotemporal patterns and interactions among climate variables, especially those related to hydroclimate, has always been an important task for geoscientists in general and climatologists in particular, mostly because it contributes significantly to better prediction and forecasting. Teleconnection is a fundamental component of the climate system that refers to the climate variability links between geographically separated regions. Teleconnections, such as El Niño Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), North Atlantic Oscillation (NAO), and the Madden Julian Oscillation (MJO), are often analyzed in their mature phase of variability with the recognition that the teleconnections have an evolving spatiotemporal scale. However, complexities are intrinsic to natural systems, and for this reason, the task of identifying patterns and interactions has always been challenging. Coupled with the existing challenges of global-warming-induced climate change, these patterns and interactions become further unusual, unexpected, and unpredictable. With these challenging realities, climate science studies globally recognize that climatic and other geophysical processes are intrinsically nonlinear and carry multiscale features and influences that are generally time-varying. This Special Issue is primarily prompted by these realizations and an implied aspiration to develop a collection of advanced studies addressing the abovementioned issues.

Teleconnections serve as an essential tool for regional hydrometeorological predictions and highlight the potential explanatory role in understanding the spatiotemporal variability of hydrological variables. There are six papers in this Special Issue related to this topic. Harry West et al. [1] focused on the spatio-temporal understanding of the rainfall signatures in Great Britain based on the North Atlantic Oscillation (NAO) rainfall response variability. They showed a stronger and more consistent NAO rainfall response, with a greater probability of more extreme wet/dry conditions. However, greater NAO rainfall variability during winter was found in the SE. A more spatially consistent rainfall response marks the summer months and finds variability in wet/dry magnitude and directionality. Wayne Yuan-Huai Tsai [2] reported the cause for the Northern Queensland Floods during February 2019 as a record-breaking sub-seasonal peak rainfall event. The event was induced by an anomalously strong monsoon depression moderated by the convective phases of an MJO and an equatorial Rossby wave. This study reported that the equatorial Rossby wave is the leading cause for the lower forecast skill. Chao Wang [3] focused on the evolution characteristics of the daily-scale Silk Road pattern and its effect on heatwaves in the Yangtze River Valley based on multi-reanalysis daily datasets and station data. The study reported that sinking adiabatic warming and clear-sky radiation warming can be considered the possible causes of the YRV heat waves. Xiaoduo Pan [4] described the refined characteristics of moisture recycling over the Heihe River Basin (HRB) using the Weather Research and Forecasting model. The study concluded that the wind dominantly transported water vapor of the HRB from the west and north directions, and the west one was much larger than the north one. In addition, precipitation over the HRB was triggered mainly by the vapor transport from the west to the east. Nachiketa Acharya [5] explored the onset of the rainy season for seven agroclimatic zones over Vietnam. The spatiotemporal characteristics of zonal onset date are analyzed using the teleconnection with Niño 3.4 anomalies. The interannual variation in the rainy season onset date is approximately two weeks across all agroclimatic zones. Central Highlands and South zones were found to have a potential for onset prediction, as both regions were linked with Nino 3.4 anomalies. Md Wahiduzzaman [6] investigated the spatiotemporal variabilities and trends of thunderstorms days over Bangladesh and their teleconnections with El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD). The Mann–Kendall test reveals an increasing trend in thunderstorms for May and June, particularly in north and northeastern regions. The connection between thunderstorms and ENSO/IOD indicates a decrease in thunderstorm activities in Bangladesh during the El Niño and positive IOD years.

The emerging spatiotemporal characteristics of extreme events due to climate variability and change helps to understand the propagation of the extreme events. There are three papers related to this topic. Kevin K. W. Cheung [7] analyzed the spatial distribution of the daily precipitation concentration index inside the Greater Sydney Metropolitan Area using Moran's spatial autocorrelation. The spatial distribution has revealed the nature and mechanisms underlying the distribution of torrential rains over space within the metropolis of Sydney under the warming climate. AVS Kalyan [8] conducted a multiscale spatiotemporal analysis of extreme events in India's Gomati River Basin. Using Sen's slope estimator and Hurst exponent analysis, the authors computed the present and future spatial variation of sixteen extreme climate indices. The study has shown that the number of dry days increased, highlighting that the basin is getting drier. Next, the periodicities and non-stationary features were estimated using the continuous wavelet transform and find a dominant two-year period in D95P has changed to the four years after 1984 and remains in the past two decades. Furthermore, the joint probability estimation using the copula theory highlights the underestimation of the return period due to the ignorance of mutual dependence. Changjun Wan [9] explored the spatiotemporal aggregation characteristics of extreme precipitation over China using the local spatial autocorrelation and spatiotemporal scanning models. Integrating both models can effectively detect the accumulation of extreme events.

Several precipitation products are available to model the hydrological behavior of watersheds, primarily derived from gauge-based observations, remote sensing, and reanalysis. This Focus Issue touches on this exciting research; for instance, Setti et al. [10] evaluate the influence of different precipitation products on model parameters and streamflow predictive uncertainty using a soil water assessment tool (SWAT) model. They showed that bias-corrected TRMM data could be a good alternative to ground observations for driving the hydrological model of forest dominated catchment over India.

Jianfeng Wang [11] presented the impacts of harsh weather conditions on the transportation system using a stratified Cox model and a heterogeneous Markov chain model, and showed that weather variables, including temperature, humidity, snow depth, and ice/snow precipitation, have a significant impact on train performance.

To improve the simulation of tropical cyclones over the North Indian Ocean (NIO), Gundapuneni Venkata Rao [12] investigated the impact of seven microphysical parameterization schemes using the ARW model. From sensitivity analysis, the WSM3 scheme simulated the cyclones Nilofar, Kyant, Daye, and Phethai well, whereas the cyclones Hudhud, Titli, and Ockhi are best simulated by WSM6. The study suggests that the WSM3 scheme can be used as the first best scheme to predict post-monsoon tropical cyclones over the NIO.

To disentangle the devastating landslides and widespread flooding over Central Chile, Piero Mardones [13] explored the freezing level distribution along the western slope of the subtropical Andes (30°–38° S) for the present climate. They estimated the changes from the 21st century using the free tropospheric height of the 0 °C isotherm (H0) as a proxy. The mean value under wet conditions toward the end of the century (under RCP8.5) is close to, or higher than, the upper quartile of the H0 distribution in the current climate. Under RCP8.5, even moderate daily precipitation can increase river flow to levels that are considered hazardous for central Chile.

Findings reported in the SI highlight and support the urgent need to consider the remote teleconnections, extreme events, multiscale variability, and dynamics of the geophysical process in general and climate process in particular. All published 13 studies contributed significantly to our existing knowledge and will appeal to the broader society of Earth scientists and modellers given the problems they face in understanding the spatio-temporal variability of the climate variables, coupled between the teleconnections and extreme events. This Special Issue advanced our understanding of these emerging patterns, teleconnections, and extreme events in a changing world for more accurate prediction or projection of their changes, especially on different spatial–time scales.

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