Hyperspectral Unmixing as an Analog Forecasting Method during Strong Monsoon Events in the Philippines

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ABSTRACT

The interaction between the monsoon winds and terrain causes rainfall along the coastal regions of western and eastern Philippine during the southwest monsoon (Habagat) and the northeast monsoon (Amihan) seasons, respectively. The destructive capabilities of heavy rainfall events arising from this interaction during active monsoon days necessitates an efficient and computationally cheap complement to our current rainfall forecasting methods.

This study applies the analog forecasting technique to predict strong monsoon rains. In analog forecasting, the rainfall distribution of different days with similar weather patterns should look similar. A day in the past with similar environmental conditions as today can be used to forecast today's rainfall. Hence, the goal of analog forecasting is to look at days in the past with similar environmental conditions as today in the hopes that rainfall then will be similar to today's rainfall. The environmental conditions used to compare historical rainfall days are the mean sea level pressure (SLP) and relative humidity (RH) obtained from the (2001-2018) JRA55 reanalysis dataset. They are chosen as SLP and RH are the main meteorological parameters that describe the air-land interaction that drive heavy monsoon rainfall in the country.

In this study, we test a novel approach using the hyperspectral unmixing method in the selection of historical days with similar weather patterns. The method selects past days with varying degrees of similarity to a target forecast day. A composite weighted ensemble mean rainfall map is then produced as the rainfall forecast. Utilization of this method requires three steps: (1) reducing data dimension, (2) unmixing the patterns' signatures, and (3) estimating the weights of each pattern. Then, rainfall from the GPM IMERGE are compiled to construct rainfall forecast maps. As a point of comparison, we also selected weather patterns of historical rainfall days using the direct correlation method where past SLP maps most correlated to the target forecast day are chosen as analogs. To assess the skill of the forecasts, accuracy scores were calculated using the observed rainfall obtained from PAGASA weather stations. The SLP, RH, and satellite-derived rainfall dataset from 2001-2020 were randomly separated into a training phase (90%) and a testing phase (10%). The training phase data were used to find the optimal SLP domains, rainfall scaling, and the weather archetypes (combination of SLP, RH, and rainfall) characterizing strong monsoon events. The testing phase data were then used as target rainfall forecast days.

Based on the forecast skill scores of the testing phase, hyperspectral unmixing and direct correlation performed equally in predicting strong Habagat and Amihan rainfall. Both methods tend to underestimate rainfall directly caused by a tropical cyclone during the Habagat season. Both methods also tend to overestimate rainfall when the continental high over China extends southeastward during strong Amihan, but does not necessarily result to heavy rainfall along east Philippines. Around half of rainfall forecasts from the test set of the two strong monsoon seasons have "above average skill" forecasts. The "above average skill" strong Amihan rainfall forecasts have threat scores ≥ 0.3, probabilities of detection ≥ 0.35, and false alarm ratios ≤ 0.15. On the other hand, the "above average skill" strong Habagat rainfall forecasts have threat scores ≥ 0.5, probabilities of detection ≥ 0.8, and false alarm ratios ≤ 0.4. The aforementioned threshold assessment scores are the overall average

scores when checking for heavy rainfall in the testing phase. The opposite holds for “below average skill” rainfall forecasts. While the results of this study do not show robust forecasting skills, some acceptable rainfall forecasts were observed. Unlocking its potential and overcoming its limiting inabilities to forecast TC-induced heavy rainfall and lack of heavy rainfall during a strong northeasterly flow requires further investigation.