RADAR-OBSERVED DIURNAL CYCLE AND PROPAGATION OF CONVECTION OVER WESTERN LUZON

Charlindo S. Torrion
MS Meteorology, IESM-UPD

Gerry Bagtasa, Ph.D.
Thesis Adviser

ABSTRACT

The interconnected effects of the land-sea contrast, local circulation patterns, and complex topography is responsible for the distinctive behavior of diurnal cycle of precipitation (DCP) and convection propagation (CP) from region to region. The Western Luzon exemplifies a north-south coastline orientation with significant elevated terrain (i.e., Cordilleras and Zambales mountain range) in the east (inland) and maritime environment to the west (offshore). This unique geographical configuration not only encourages the formation of convective storms but also makes accurately characterizing diurnal variability difficult due to the complex interplay of local and large-scale atmospheric dynamics. The DCP and CP over Western Luzon was characterized using multiple spatial data sources (i.e., Subic radar, GPM IMERG, WRF simulation, and ERA5 datasets). Fourier harmonic analysis (FHA) was used to delineate the peak amplitude and timing of the rainfall features (i.e., occurrence frequency, intensity, and accumulation). Multivariate empirical orthogonal function (mEOF) was used to characterize the spatiotemporal characteristics of rainfall from GPM IMERG, and the variance explained by the DCP as influenced by temperature and relative humidity (RH) from ERA5. The land/sea breeze, transport of moisture, vertical profiles of temperature and RH, the moist static energy (MSE) and convective available potential energy (CAPE) was investigated to understand the environmental conditions associated with DCP and CP. The study area was divided into two rainfall regimes, the offshore and inland regime, which is further divided into two, OR1 and IR1, representing the northern, and OR2 and IR2 for the southern portion of the study area.

A strong agreement among the results of the FHA for DCP from Subic radar, GPM IMERG, and WRF-run for all regimes was observed; a peak time from afternoon to early evening (13-18 LST) except for offshore regime in WRF-run which observed an early morning peak (5-8 LST) and OR1 in Subic radar with a midday peak (11-13 LST); a peak amplitudes of 13-14%, 37-54%, 66-72% (occurrence), 1.63-1.72 mm/hr, 0.99-1.55 mm/hr, 1.24-1.52 mm/hr (intensity), and 0.72 mm/hr, 0.36-0.80 mm/hr, 1.24-1.52 mm/hr (accumulation) for GPM IMERG, Subic radar, and WRF-run, respectively. A strong goodness of fit is also observed with variance ratios > 60% and correlation coefficients > 0.70. Secondary peaks in the early morning were also detected in all regimes that were attributed to the semidiurnal cycle (sDCP). Using Hovmoller diagram, the propagation of convection was observed to propagate from offshore to inland with peaks around afternoon to evening (13-18 LST) along the coast of Western Luzon.

The mEOF analysis shows that first and second mode (mEOF1 and mEOF2) explains 13.02-31.55% of the joint variance of rainfall, temperature, and RH that is attributed to the DCP with R=0.9 for temperature and R=-0.9 for RH. The third and fourth modes (mEOF3 and mEOF4) were also computed and were attributed to the sDCP with joint variance explained of 5.65-6.89%. The normalized principal components (PCs) of the four modes of mEOF were computed and plotted against hours of day (LST). Two distinct peaks were detected with the stronger peak being in the 18 LST and a weaker one at 6 LST suggesting a clear diurnal cycle.

Lastly, the diurnal variation of the correlation coefficients of instability parameters reveal a strong positive correlation (R up to 0.8) for MSE and CAPE vs temperature, while a strong negative correlation (R up to -0.7) for MSE and CAPE vs RH, with peaks detected at 6 LST and 18 LST and an extreme variation during midday where solar heating is at its maximum. IR1 is observed to significantly deviate from the rest of the rainfall regimes exhibiting extreme diurnal variations of correlation among instability indices. This highlights the effects of the Cordilleras to the diurnal cycle in this area. A case study of comparing quiescent vs thunderstorm days was conducted to examine their difference using T-test. The comparisons show a significant difference (at 95% confidence level; p-value<0.05) between the two.

This study shows an intricate interplay of complex geography and environmental conditions that drives the diurnal cycle. It is revealed that diurnal cycles of precipitation exhibit a dominant peak in amplitude during the late afternoon to evening especially inland (DCP), and a weaker secondary peak during the early morning offshore (sDCP).

Keywords: diurnal cycle of precipitation, propagation of convection, rainfall