Rainfall over the Asian coastal regions observed by TRMM precipitation radar: Role of orography, diurnal cycle, and intraseasonal oscillation

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For over 16 years, the Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR), the first space-borne radar, provided the most reliable precipitation products in the tropics and subtropics. Using the dataset, we examine rainfall over the Asian coastal regions, focusing differences between the western coastal region of India (Western Ghats; WG) and Indonesian maritime continent (IMC).

TRMM PR has shown that conventional satellite data such infrared radiation (IR) and outgoing long-wave radiation (OLR) does not capture even rainfall mama over the WG region. In contrast to the offshore locations determined in previous studies based on the IR and OLR, TRMM PR observed rainfall maxima on the windward slopes of the WG region. IR and OLR have been used under the paradigm that heavy rainfall is associated with deep convection, which is generally attributed to observational studies in the United States. However, heavy rainfall can be caused by shallow orographic convection over moist Asian coastal regions.

The prevailing view that the coastal precipitation in the tropics results from daytime heating over land, which results in land–ocean temperature gradients due to the smaller heat capacity of land compared to that of ocean, is generally attributed to observational studies of the IMC. The rainfall in the WG region exhibits low diurnal variability, implying that the rainfall is not primarily driven by thermal convection, but by mechanical convection. Large rainfall amounts with small diurnal amplitudes are observed over the WG under strong environmental flow perpendicular to the coastal mountains, and vice versa. Diurnal-driven migrating systems are observed over the WG under weak environmental flow, but do not determine the seasonal distribution of summer monsoon rainfall, explaining why the rainfall maxima are not observed offshore.

Composite analysis of the boreal summer intraseasonal oscillation (BSISO) shows that the rain anomaly over the WG slopes lags behind the northward propagating major rain band. The cyclonic systems associated with the BSISO introduces south-west wind anomaly behind the major rain band, enhancing the orographic rainfall over the WG, and resulting in the phase lag. Diurnal variations in rainfall over the WG regions are smallest (largest) during (preceding) the strongest BSISO rainfall anomaly phase. The change in the diurnal cycle of rainfall throughout an intraseasonal cycle over the WG is different from that over the IMC where the amplitude of the diurnal cycle and the daily mean rainfall over the IMC are greatest shortly before the large-scale active Madden-Julian oscillation (MJO) envelope arrives, with a lead time of one-eighth of an MJO cycle. It is interesting to note that IR and OLR does not act as a good proxy for rainfall even over the IMC where heavy rainfall is associated with thermal-driven deep convection.