Challenges for a systematic understanding of the precipitation process in Asian countries

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Asian countries exist in tropical, subtropical, temperate, and subarctic zones, which includes semi-arid and highland area; therefore, a background synoptic-scale forcing and a surface boundary forcing for regional-scale climate differ depending on the regions. Toward the establishment of a new Regional Hydro-climate Project for the Asian monsoon region under WCRP/GEWEX/GHP, we propose several challenges for understandings of (1) precipitation variability over multiple-timescales and their interactions by means of in-situ observation, space and ground remote sensing, and modeling, (2) key processes that affect precipitation variability in multiple-timescales, (3) possible contributions of surface conditions including SST, land cover, soil moisture, snow, and topography to precipitation variability.
As an example, the largest annual precipitation amount is recorded over the Meghalaya Plateau in South Asia, which would be caused by a complex interaction of diurnal, intra-seasonal, and seasonal variations during the Asian summer monsoon season. Fujinami et al. (2017, JGR) suggests that a low-level barrier jet is accelerated over a stable layer in the nighttime and transports moist air effectively to the south of the Meghalaya Plateau, which is a key mechanism to cause heavy precipitation (Fig. 1). The meso-scale convective systems (MCSs) developed over the South Asia also would be a hot topic in terms of heavy precipitation occurrence, a moistening in the lower stratosphere, and moisture transport over the Himalayas and the Tibetan Plateau (e.g., Dong et al. 2016, Nature Communications). For these issues, an intensive observation under the cooperative system among the Asian counties is essential to reveal the diurnal variation in the planetary boundary layer (PBL) structure and the atmospheric water cycle in the multi-sphere. Meanwhile, the high resolution experiments (less than 2km) could be conducted using regional climate models because of a current progress of computational resources, which would be valuable for evaluations of a diurnal variation in precipitation characteristics over the precipitous mountains (e.g., the Himalayas and the Meghalaya Plateau) and impacts of the surface conditions on precipitation processes.
The new findings obtained from the studies in the South Asia, such as the occurrence of nocturnal low-level jet, the effect of the MCS on the moisture transport, impacts of SST and land surface condition on precipitation, and the simulation skill of regional climate model for the heavy precipitation over the complex topography etc., should be compared them in other Asian countries and/or could be applied to the understanding of their physical processes in other regions. The understanding of global common and regional/seasonal-dependent sensitivities of precipitation characteristics to the surface conditions over the various climate conditions is also interesting.

Keywords: Asian summer monsoon, Precipitation processes, land-atmosphere interaction, observations and modelings, Atmospheric water cycle

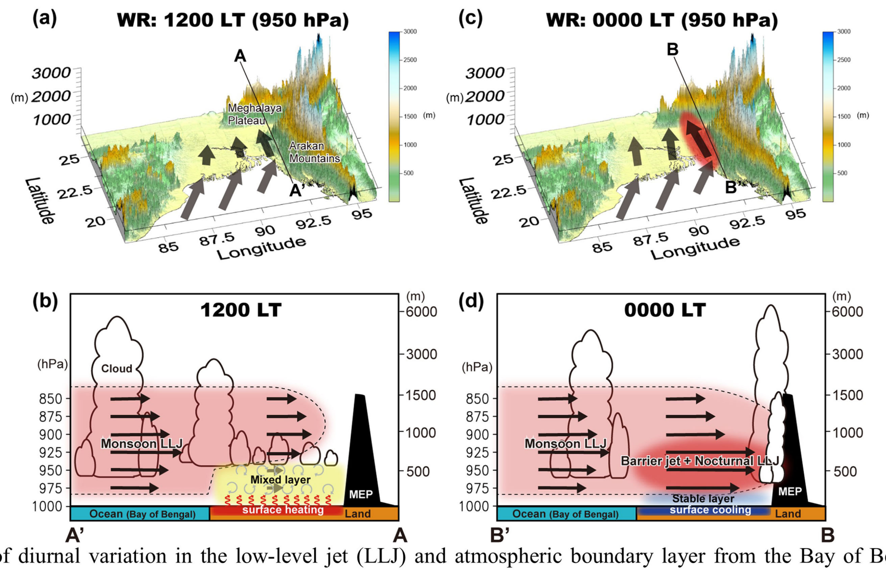

Figure 1 Schematics of diurnal variation in the low-level jet (LLJ) and atmospheric boundary layer from the Bay of Bengal to the Meghalaya Plateau (MEP) under the westerly regime (WR). (a) Representative horizontal wind at 950 hPa over the ocean and land at 1200 LT with 3-D topography. The vector length is proportional to the wind speed. (b) Vertical section along the line A–A0 in Figure a. Arrows over the ocean and land indicate representative horizontal wind speeds in the two regions at pressure levels in the lower troposphere that represent the vertical profile of the LLJ toward the Meghalaya Plateau. Shading enclosed by the dotted line indicates the envelope of the monsoon LLJ. (c) As in Figure a but for 0000 LT. The elliptical area parallel to the Arakan Mountain indicates a strong LLJ due to the barrier jet and nocturnal jet that cause the nocturnal rainfall over the southern slope of the plateau. (d) As in Figure b but for 0000 LT along the line B–B0 in Figure c. (Fujinami et al. 2017)