

Characteristics of convective and stratiform precipitation at seasonal scale in Asia based on measurements by precipitation radar onboard TRMM satellite

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Abstract

The precipitation frequency, intensity and vertical structure of convective and stratiform precipitation at seasonal scale in Asia are investigated based on measurements of TRMM Precipitation Radar (PR) in the latest ten years from 1998 to 2007. Results indicate greater than 5 mm/d precipitation seasonally in East Asia besides heavy monsoon rainfall in South Asia. The investigated rain intensity of both convective and stratiform precipitation is weaker over land than over ocean. The mountain forcing effect on precipitation in Asia is obvious and produces windward heavy rain bands and higher precipitating frequencies, while weaker precipitation usually accompanies with the leeward mountain regions. Results also show a convective precipitation frequency less than 3% and exceeds 3% for stratiform in Asia. Convective precipitation frequencies in spring announce much more convective activities occurring in the Indochina Peninsula, southern China and South China Sea than in the Indian subcontinent, which conforms that the onset of East Asian monsoon is earlier than that of Indian monsoon, while the decay of summer monsoon originates from the mainland of China. The seasonal variability of precipitation profiles for both convective and tratiform precipitation shows stronger variability in the extra-tropical regions than in tropics, stronger over land than over ocean in the same latitude. Results also expose four and three layers in the vertical direction according to distributions of rain rates for convective and stratiform precipitation, respectively.

Data and Methodology

The data, 2A25 from 1998 to 2007, used in this study is the TRMM standard products issued by Goddard Space Flight Center. The data of 2A25 retrieved by the echo signals of TRMM PR supply rainfall intensity at each swath with a horizontal resolution of 4.3 km at the nadir and a vertical resolution of 250 m from the Earth's surface to 20 km altitude. According the TRMM rain classification algorithm (Steiner et al. 1995; Awaka et al. 1997), the data also contain information on rainfall types. Briefly, a rain profile is classified as stratiform if PR detects a bright band near the freezing level. If no bright band exists and any value of radar reflectivity in the beam exceeds a predetermined value of 39 dBZ, the profile is classified as connective.



The distribution of total samples at resolution 0.5deg detected by TRMM in summer Asia (60°E~160°E, 0°~40°N). It indicates more samples in extratropics than in tropics because relatively smaller cycle diameter in the middle latitude induces higher satellite

So the heterogeneous should be considered to calculate the spatial distributions of seasonal-mean precipitation in 0.5deg horizontal resolution. The seasonal precipitation frequency is defined as the fraction of the precipitating pixels detected by PR to total detected pixels including nonprecipitating pixels at each grid. While the conditional rain rate is named as the ratio of rain total to total precipitating pixels at each grid.

Pixel	Spring	Summer	Autumn	Winter
Total	811428215	796116046	797820911	787425566
Convective	5701735 (0.7%)	7190036 (0.9%)	4130925 (0.5%)	2872831 (0.4%)
Stratiform	24537438(3.0%)	31613873(4.0%)	22056202(2.8%)	16648046(2.1%)
other	8886572 (1.1%)	10743133(1.3%)	6720921 (0.8%)	6249394 (0.8%)

Seasonally total pixels and rain pixels in Asia detected by TRMM Precipitation Radar from 1998 to 2007, a percentage at each bracket is represented for precipitation possibility in seasonal scale.



The climatological distribution of precipitation is dominated by West Pacific subtropical high (WPSH) and monsoon flow at low troposphere. Summer is a bloom season of precipitation in Asia due to WPSH shifting northwards.



Seasonal distribution of

Precipitation intensity



Seasonal distribution of mean conditional convective and stratiform rain rate in Asia in winter (a). spring (b), summer (c), and autumn (d) in last ten years, which indicates more than 10mm/h me convective rain rate in Asia while less than 4mm/h mean intensity for stratiform precipitation.

Precipitation profile

Seasonal variations of mean convective and stratiform precipitation profiles in the six typical regions, Indian subcontinent (a), Bangladeshi Bay (b), East China Sea and the ocean near its east part (c), Eastern mainland of China (d), South China Sea (e), Warm Pool in Western Pacific (f). The plots expose clearly seasonal variability of over land and in extra-tropics.



Precipitation cross-section plot

Results

Height-longitude cross-section of convective and stratiform rain rate (unit: mm/h) along 5°N, 15°N, 30°N in Winter (left panel) and Summer (right panel). It shows relatively flat top of stratiform against convective sharp top due to vigorous updraft inside convective precipitating clouds. Generally, a higher top in summer in extra-tropics, especially over land, is distinctly identified.



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Precipitation frequency

Rain rate distribution

Generally, the frequency of convective precipitation ranges from 0.5% to less 5% in most part Asia contrary to 3~10% higher frequency of stratiform precipitation in the same region.



Seasonal distribution of convective and stratiform precipitation frequency in Asia in winter (a) spring (b), summer (c), and autumn (d) from 1998 to 2007