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Summer Cloud Precipitation Characteristics

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Abstract

The impact of the three-step staircase topography on the features of precipitation around latitude 30°N in East Asia has not received much thorough research. This study used a combined dataset created from measurements made by the Tropical Rainfall Measuring Mission Precipitation Radar and Visible and Infrared Scanner from 1998 to 2012 reanalysis datasets to investigate the climatological characteristics of summer convective and stratiform precipitation on horizontal distribution, vertical structure, and diurnal variation in East Asia. Results demonstrate that the three-step staircase topography, particularly between the first staircase and its eastern section, clearly differs in terms of rain frequency, mean rain rate, and maximum echo reflectivity factor. Several from the East China Sea westward to the eastern portion of the first staircase, through the third staircase, and the second staircase along 30°N, there are slight variations in the echo-top height, the cloud-top height, the maximum echo reflectivity factor, and its corresponding height. However, the rate of precipitation fell twice as fast westward along this latitude, in response to the indirect effects of aerosols and humidity, respectively.

Keywords: VIRS (Visible and Infrared Scanner) • TRMM (Tropical Rainfall Measuring Mission) • Precipitation • Atmospheric

Introduction

The strongest echo reflectivity factor of precipitation in the second and third staircases, including the East China Sea, appears in the early morning, which is consistent with the diurnal variation of the convective precipitation reflectivity factor, which showed that the development of convection in the eastern part of the first staircase gets at the maximum from the early afternoon to sunset compatible with the atmospheric circulation's daily oscillations. Due to the favorable weather, environment, and geography at this latitude, the majority of human civilizations began to develop about 30°N. From the Tibetan Plateau in the west to the ocean in the east, East Asia's geography gradually flattens through mountains, basins, and plains. The topography and monsoon activity both have an impact on the distribution of the changes in precipitation [1].

The right atmospheric conditions—such as circulation, aerosols, air disturbance triggers, favorable atmospheric temperature, humidity conditions, etc.—allow precipitation to occur. Topography is one of these factors, which has an impact on significant impact on precipitation.To explore how terrain affects precipitation, numerical models and parameterized techniques based on data from satellite and meteorological station observations are frequently utilized. For instance, used data from 22 meteorological stations and 20 years of monitoring to examine how geography affected the structure of typhoons over China and Taiwan and used data from a ground-based dual-doppler radar system to study the orographic impacts on a squall line system over Taiwan. They discovered that the vertical structure and horizontal dispersion of precipitation over China and Taiwan were altered by the country's complicated hilly geography. Barros and Kuligowski (1998) established strong evidence of the following based on data from radiosondes and rain gauges The Appalachian Mountains' orography and heavy precipitation cells are linked, with the center of the storm's precipitation closely following local orographic features. As a result of their analysis of satellite remote sensing data hypothesized that the terrain affects the spatiotemporal distribution of precipitation, the spatial variability of the diurnal cycle of convective activity, and the spatial variability of the diurnal cycle of convective activity on spatial scales ranging from the order of a few kilometers up to the continental scale. They discovered a convergence zone from northern India to the Himalayas that is controlled in the middle Andes, (2017) and demonstrated how geography affects the diurnal cycle of precipitation and related meteorological processes [2-5]. The Goddard Space Flight Center/National Aeronautics and Space Administration's TRMM PR 2A25 and VIRS 1B01 version 7 datasets during the summer season (June-August) from 1998 to 2012 were used. The precipitation information provided by the TRMM PR 2A25 product, which is a pixel-level data product, includes the near-surface RR, the type of rain (stratiform, convective, and other), and the three-dimensional radar reflectivity in each pixel. It has a horizontal resolution of 4.5 km and a vertical resolution of 250 m from sea level to 20 km and is based on the precipitation algorithm given by the Goddard Space Flight Center. An orbit-level data product with a horizontal resolution of 2.1 km at nadir is the VIRS 1B01 product. The reflectivity at five is provided wavelengths of 0.63 m, 1.6 m, 3.7 m, 10.8 m, and 12.0 m, or the visible to the thermal infrared band. Cloud top information can be observed in the far infrared channel at 10.8 m; when the cloud top is higher, the infrared brightness temperature in this channel is lower. Therefore, the height or phase state of the cloud-top was inferred using the infrared brightness temperature at the 10.8 m channel (TB10.8). The distribution of the atmospheric stability index (K-index) and the typical AOD over East Asia throughout the summer. It reveals a significant amount of instability (>35°C) in the first staircase's eastern section and the second staircase's southwest region, which is related to topographic uplift forcing. Due to the confluence of warm and wet air, the southern section of the third staircase (>30°C) is more unstable than the northern part. The eastward extension ridge of the South Asian high and the westward extension ridge of the western Pacific subtropical zone, respectively, dominate the middle (500 hPa) and upper (200 hPa) atmospheric circulations along the 30°N zone. As a result, the zone at 30°N serves as a zone of transition. of instability in the southern region of eastern China and the northern region of stability. According to earlier research, the atmospheric instability over the plateau's eastern portion is related to convergence and convection brought on by the terrain's dynamic forcing, whereas the atmospheric instability deep inside the plateau is primarily brought on by the underlying surface's thermal forcing. The strength of the airflow in the vertical direction is connected to the location of the maximum precipitation echo, which is primarily related to large particles The position of the particles rises with increasing airflow and vice versa [6-8]. The Maximum Echo Reflectivity Factor (MERF) of precipitation and its accompanying height is distributed spatially. Similar to how the mean RR is distributed spatially, the mean MERF of precipitation is much lower over the plateau (27 dB) than in its eastern part. The third staircase is the greatest (>37 dB) in the distribution of the mean MERF of convective precipitation, with the ocean and the second staircase coming in second and third, respectively. and the tiniest stair on the first flight. Except for the first staircase, stratiform precipitation's mean MERF is>27 dB and has a uniform distribution. The output from the satellite instrument's thermal infrared channel is frequently used to determine the Cloud-Top Height (CTH) and surface RR. The GOES Precipitation Index inversion technique, for instance, links higher CTH (lower infrared brightness temperature) with a higher likelihood of precipitation (Xie and Arkin, 1997). As a result, the distribution of the mean TB10.8 in East Asia (right-hand panels).

The first staircase has the highest ETH all>7 km, which is compatible with the lowest (238 K) TB10.8. Convective or stratiform precipitation, the ETH is essentially the same in the second and third staircases, while the cloud-top TB10.8 in the third staircase (including the Sichuan Basin) is approximately 5 K lower than that in the second staircase, proving that the third staircase's CTH is greater than that in the first. The TB10.8 of the two regions is nearly identical (234 K-242 K), especially in the 30°N zone, even though the ETH of the third staircase is higher than that of the eastern ocean. This shows that the third staircase's CTH is comparable to the eastern ocean's, but that its ETH is higher, which can be attributed to thermal forcing from the land surface during the summer. In both the third and second staircases, the vertical structure of the echo for convective precipitation is essentially the same. In contrast to the unequal distribution of the echo above 4.5 km, the echo above 32 dB is dispersed at a height of approximately 4.5 km. Strong convective activity in the third and second stairs during the summer is indicated by the high ETH (16 km–18 km). As in the case of the difference in precipitation profiles between eastern China and the East China Sea, the height of the mean echo intensity >32 dB drops to about 4 km in the oceanic region, and the intensity and height of the echo above this height are also lower than those in the third staircase. the first flight of stairs The majority of mean echo intensity over 5 km altitude is 30 dB with the ETH 17 km, except for a few echo intensities of 30 dB-34 dB at the surface (below 5 km). Near 95°E, the ETH is at its lowest point (about 14 km).

Compared to convective precipitation, the mean echo intensity of stratiform precipitation is more consistent. The third and second staircases clearly show the bright band (25 dB-28 dB) around, a distinct change from the ice phase to the water phase. Under the height of the brilliant band, the echo intensity is often maintained at 25 dBZ–27 dBZ, although near the surface in the eastern half of the second staircase and the ocean, it increases significantly (27 dB–30 dB). The rise or variation of Increased or constant echo below the bright band height indicates whether or not stratiform precipitation particles collide as they descend. At the peak of stratiform precipitation in the third and second stairs, there is a sizable echo of 21 dB–25 dB. This suggests that the stratiform precipitation system's upper layer contains more ice particles than the convective precipitation system does.

The melting layer of convective precipitation is thicker than that of stratiform precipitation, as seen by the 1 km difference in height with 35 dB and 25 dB for convective and stratiform precipitation, respectively. The trumpet-shaped terrain on the southeast Tibetan Plateau, which has a steep slope between 30°N and 95°E, is the cause of the low ETH of the two types of precipitation close to 95°E. Separate research will be done on the southeastern Tibetan Plateau's precipitation characteristics. There is no question that the conditions along 30°N in East Asia have a significant impact on precipitation [8]. The ocean to the third staircase, the mean near-surface temperature remains largely constant at 26°C to 28°C, but the DDP gradually lowers from 3.9°C (ocean) to 2.7°C (land), then rises to roughly 4.6°C in the third staircase. The mean temperature and DDP rise within the second staircase, with the highest values being 26°C and 5.3°C, respectively, possibly as a result of the influence of the mountains and basin, from the western part of the third staircase to the second staircase, with the lowest values being 24 and 3.9°C. The second staircase's eastern section has a low temperature but a high humidity level.

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