Global Drop Size Distribution in Liquid Phase and its Seasonal Variability Observed by GPM/DPR

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Summary

- Mass-weightened mean drop size (Dm) by GPM/DPR was analyzed statistically. It was found that Dm varied seasonally and the signals were statistically significant.
- Focusing on the seasonal variations over the northwest Pacific Ocean, Dm varied with respect to the precipitation characteristics, such as precipitation top height and stratiform ratio.
- Seasonal change of dominant precipitation systems can be related to the drastic seasonal and regional change of Dm.

Introduction

Drop size distribution (DSD) information is one of the key factors characterizing precipitation and closely related to the formation of precipitation through microphysical processes for clouds and precipitation. **DPR** onboard **GPM** core satellite provides DSD information based on the differential scattering properties of the two frequencies. Furthermore, it is the world's first space-borne precipitation radar to observe precipitation over the mid-latitudes.

In this study, **we discover the global distribution of mean drop size and its relationship to large-scale distributions of precipitation characteristics using four years of the GPM/DPR observations** .

Used Data

- Duration: from July 2014 to May2018 (4 years)
- Domain: 60ºS - 60ºN, global

- GPM/DPR Level-2 Version 05 product
  - **Dm** (mass-weighted mean diameter) [mm]
  - **R** (rainfall rate in nearsurface with liquid phase) [mm/h]
  - Precipitation top height (max height with R>0.3 mm/h) [km]
  - Stratiform ratio (ratio of stratiform to all precipitating pixels)

- Japanese 55-year reanalysis (JRA-55)
  - SLP (sea level pressure) [hPa]
  - 850 hPa horizontal winds [m/s]

Result 1: 4-year mean distribution of Dm and R

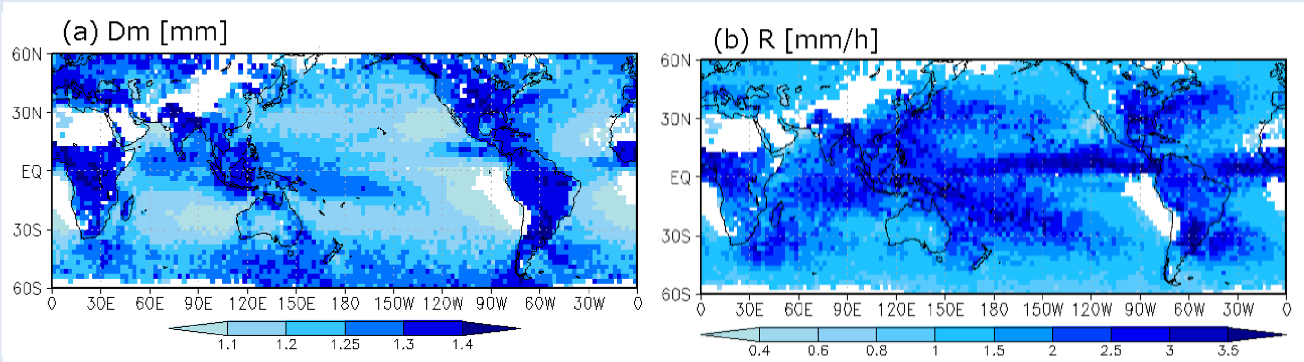

Fig.1 Four-year annual mean value (conditional) for (a) Dm in mm and (b) R in mm h−1 at clutter-free bottom level.

∗ Dm is generally larger over land than over the oceans.

∗ Although R-Dm relationship is assumed in the algorithm, the relationship is not a simple one-to-one relationship, especially over ITCZ, SPCZ, and midlatitudes in the Pacific Ocean.

Result 2: Seasonal difference of Dm and R

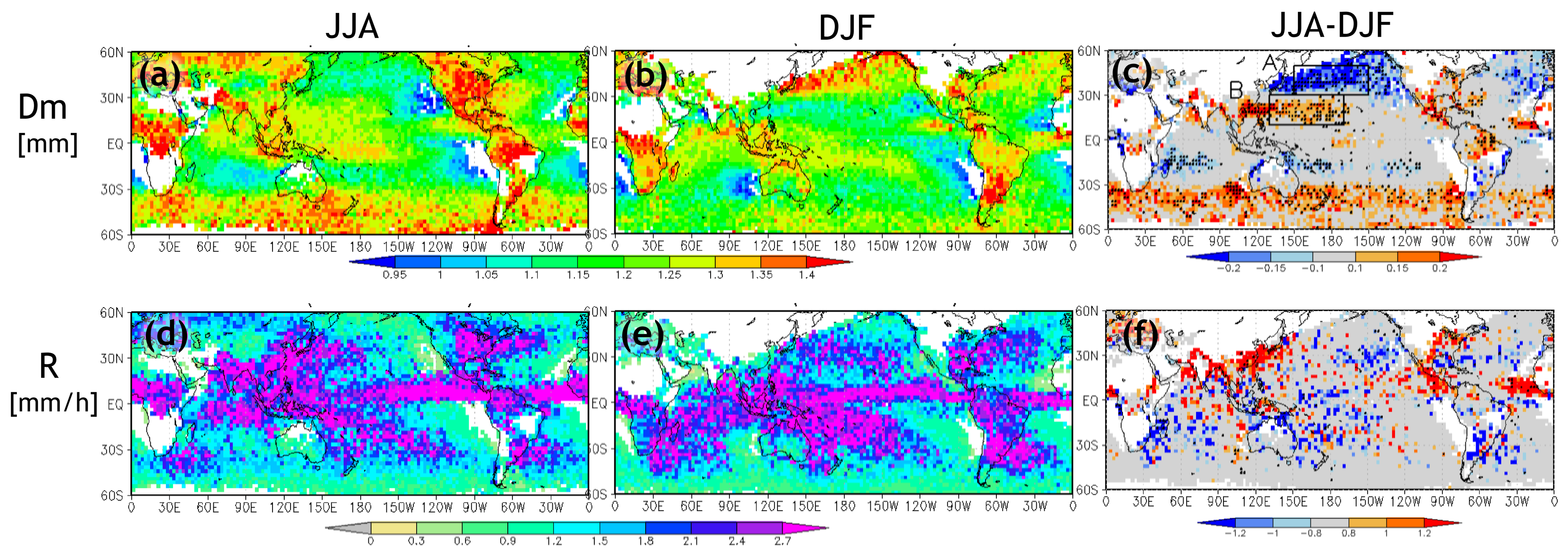

Fig.2 4-year 3-month mean value of (a-c) Dm [mm] and (d-f) R [mm/h] in (a,d) JJA, (b,e) DJF and (c,f) JJA-DJF. Black dots in (c,f) indicate the boxes with statistically significant difference at a 99% confidence level using the Welch's t test.

∗ Dm shows statistically significant seasonal variations especially over the oceans (Fig.2c) while R does not so (Fig.2f).

∗ The drastic and systematic changes in Dm can be seen over the oceans, especially in the Pacific Ocean (Fig.2c).

∗ Focusing on the northwest Pacific Ocean, Dm is smaller in JJA and larger in DJF over midlatitudes (region A) while opposite trend is seen over subtropics (region B).

Result 3: Seasonal difference of precipitation characteristics and atmospheric environment over the northwest Pacific Ocean

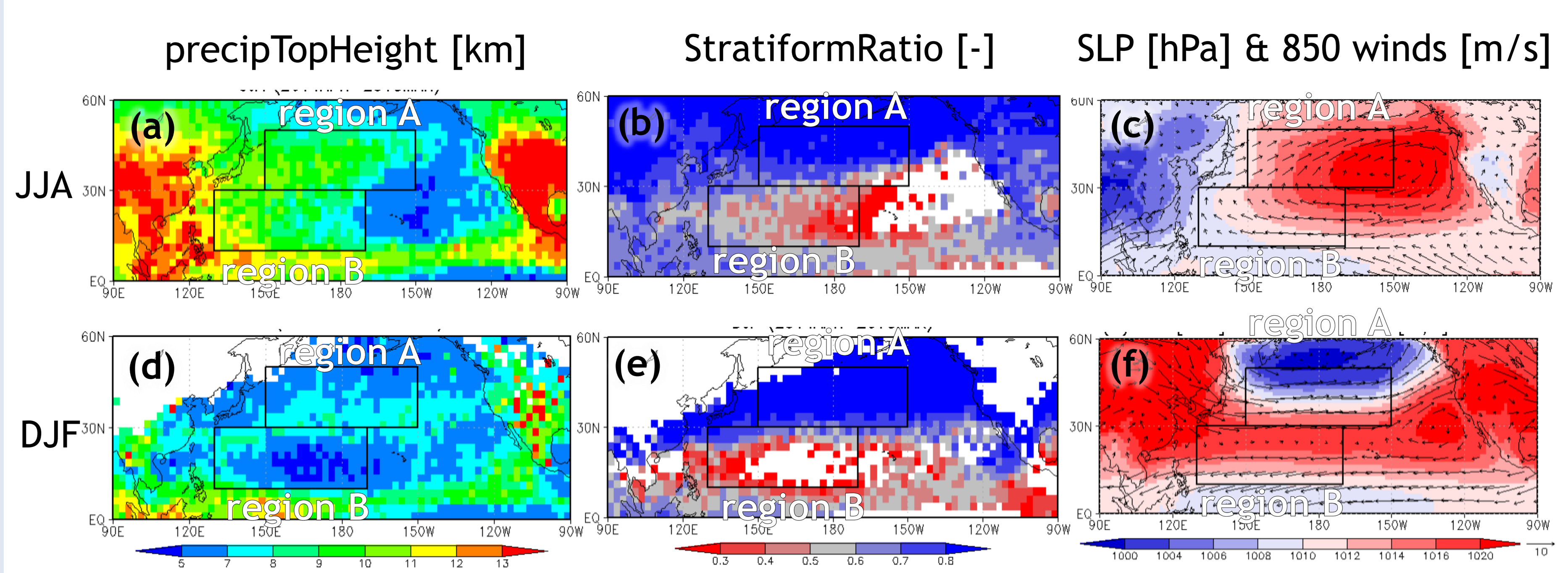

Fig.3 4-year 3-month mean value of Precipitation top heights [km], Stratiform ratio, SLP [hPa], and 850 winds [m/s]. Black open squares show region A in midlatitudes and region B in subtropics.

Result 4: Pixel-based R-Dm relationship and vertical profiles of R

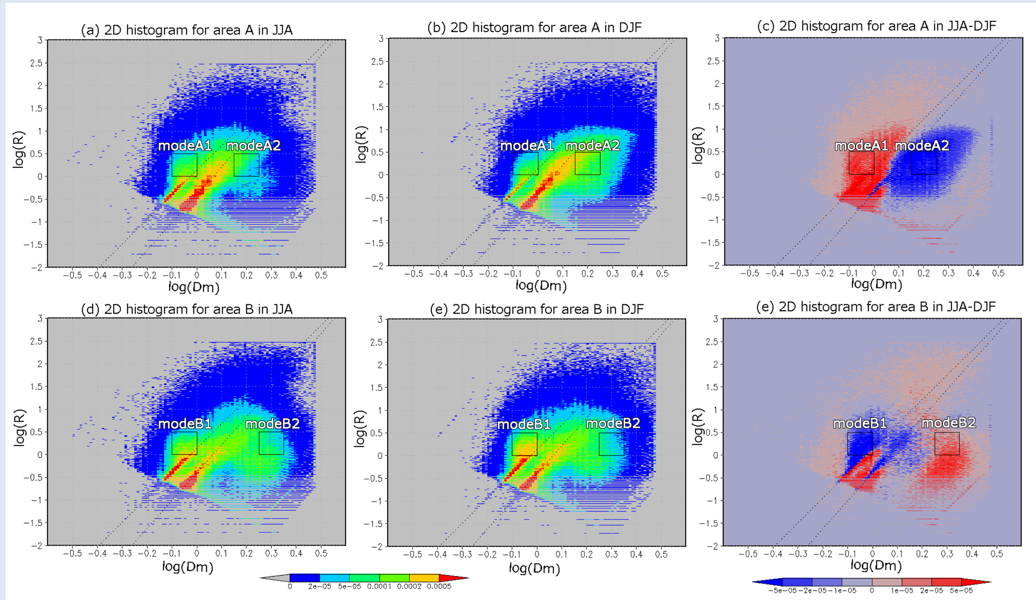

Fig.4 Joint histogram of pixel-based R-Dm relationship

∗ Assumed R-Dm model in the DPR algorithm; (ε: an adjustment factor) $R = 0.401\varepsilon^{4.649} Dm^{6.131}$ (stratiform), $R = 1.370\varepsilon^{4.258} Dm^{5.420}$ (convective)

∗ The range of Dm becomes broader when log R is within the narrow range from -0.5 to 1 (Fig.4), which may cause Dm to vary even if R has no significant changes (Fig.2).

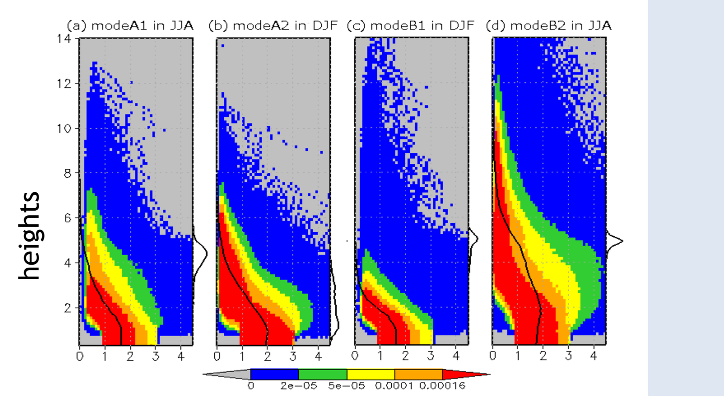

Fig.5 Joint histogram of vertical R profile.

∗ Vertical structures of R differ in each mode in Fig.4 and season even if the mean R at the near surface is around 1.5 – 2 mm/h (Fig.5).
- **region A**: The 0º C level is lower in DJF (Fig5b) than JJA (Fig.5a), consistent with results that ice-based particles exist in upper levels in DJF (not seen).
- **region B**: Mean profile is below 0º C level in DJF (Fig.5c) while the precipitation top reaches 10km in JJA (Fig.5d).

Discussion: Possible linkage between Dm change and dominant precipitation systems

	Dm change	Results of precip. characteristics and atmospheric environment	Dominant Precipitation system
Regions A and B In JJA	-	- Higher precipitation top heights: more than 8km (Fig.3a). - Both stratiform and convective exists (not seen). - The North Pacific High is dominant (Fig.3c).	**Organized Precipitation system** Baiu precipitation might be related to the organized precipitation in area A while tropical mesoscale convective systems and/or tropical disturbance can be a contributor to be categorized as organized precipitation systems in area B.
Region A in DJF	Larger in DJF than in JJA over region A (mid latitude)	- Moderate precipitation top heights: 5-8km (Fig.3d). - Higher stratiform ratio: more than 80% (Fig.3e). - corresponding to high-gradient region in SLP, and the Aleutian low stayed in the northern part of region A (Fig.3f).	**Extratropical frontal systems** It is found that heavy ice precipitation exists in upper level in DJF over area A (not shown). There is a possibility that large rain drops are formed originally from graupel or hail in ice-based precipitation and by melting at near surface.
Region B in DJF	Smaller in DJF than in JJA over region B (subtropics)	- Lower precipitation top heights: less than 7km (Fig.3d). - Lower stratiform ratio: less than 50% (Fig. 3e). - corresponding to the subtropical high and trade wind region (Fig.3f).	**Shallow convective systems** is dominant and related to smaller Dm in DJF over subtropics. The trade wind inversion suppresses convection to the upper levels, leading to low-level convective cumulus and congestus.