Warm Rain Observations from the EarthCARE Cloud Profiling Radar

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Warm rain – Introduction

"Warm rain" refers to rain produced in the absence of ice-phase processes

Warm rain is an observational challenge since they are often close to the surface, thin, and not raining very intensely

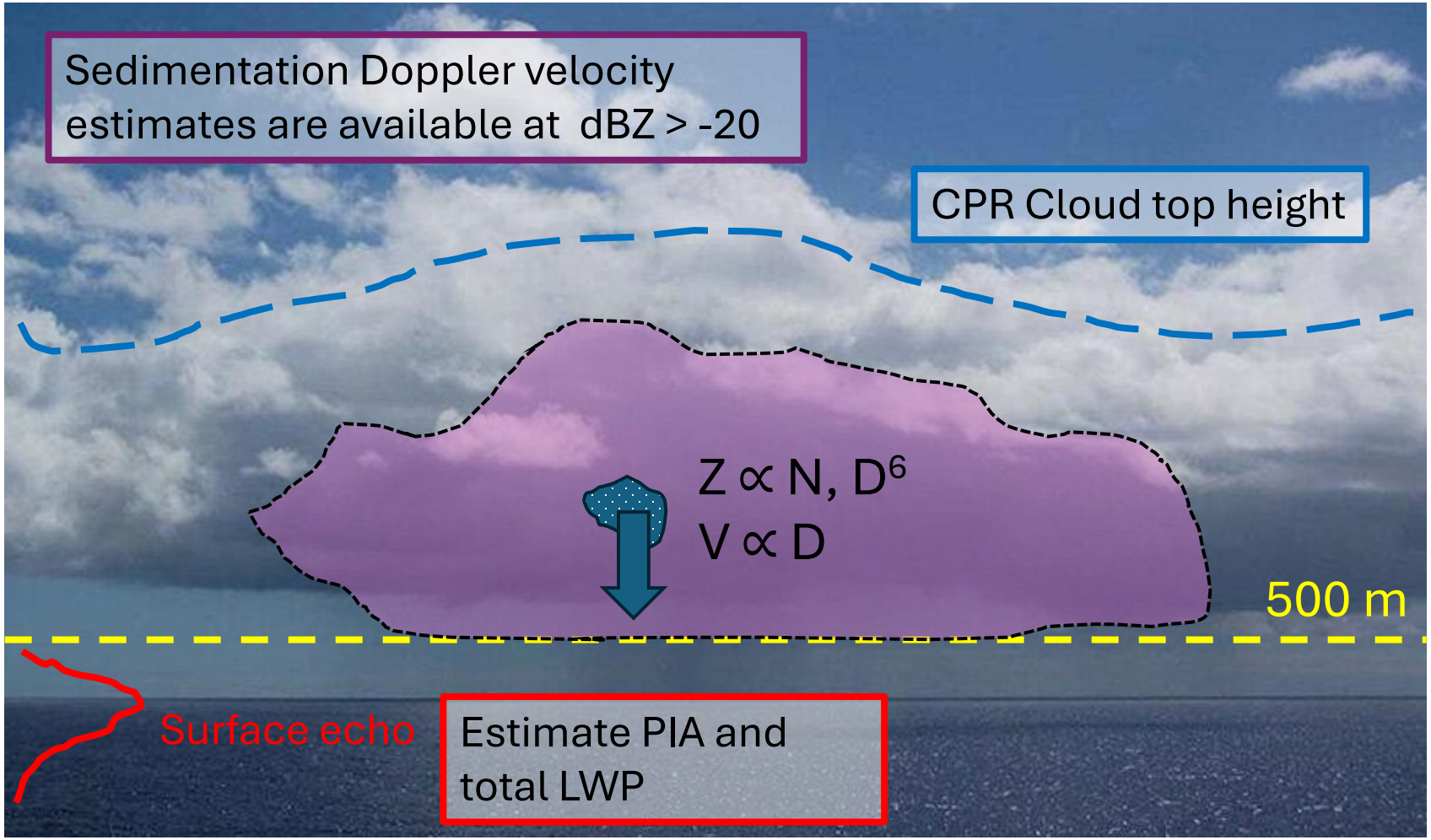
Probability of Precipitation (POP): Implications for aerosol-cloud interactions

Rainfall rate and Virga Depth: Implications for BL energetics

The tendency is for models to produce precipitation that is too frequent, as already noted in past studies.

Stephens et al., 2010: Dreary state of precipitation in global models

Warm rain and EarthCARE CPR Oceanic Observations



Estimates of:

Total Liquid Water Path
Cloud thickness

Using an assumed particle size distribution, estimates of:

Drizzle/rain characteristic particle size (D_0)

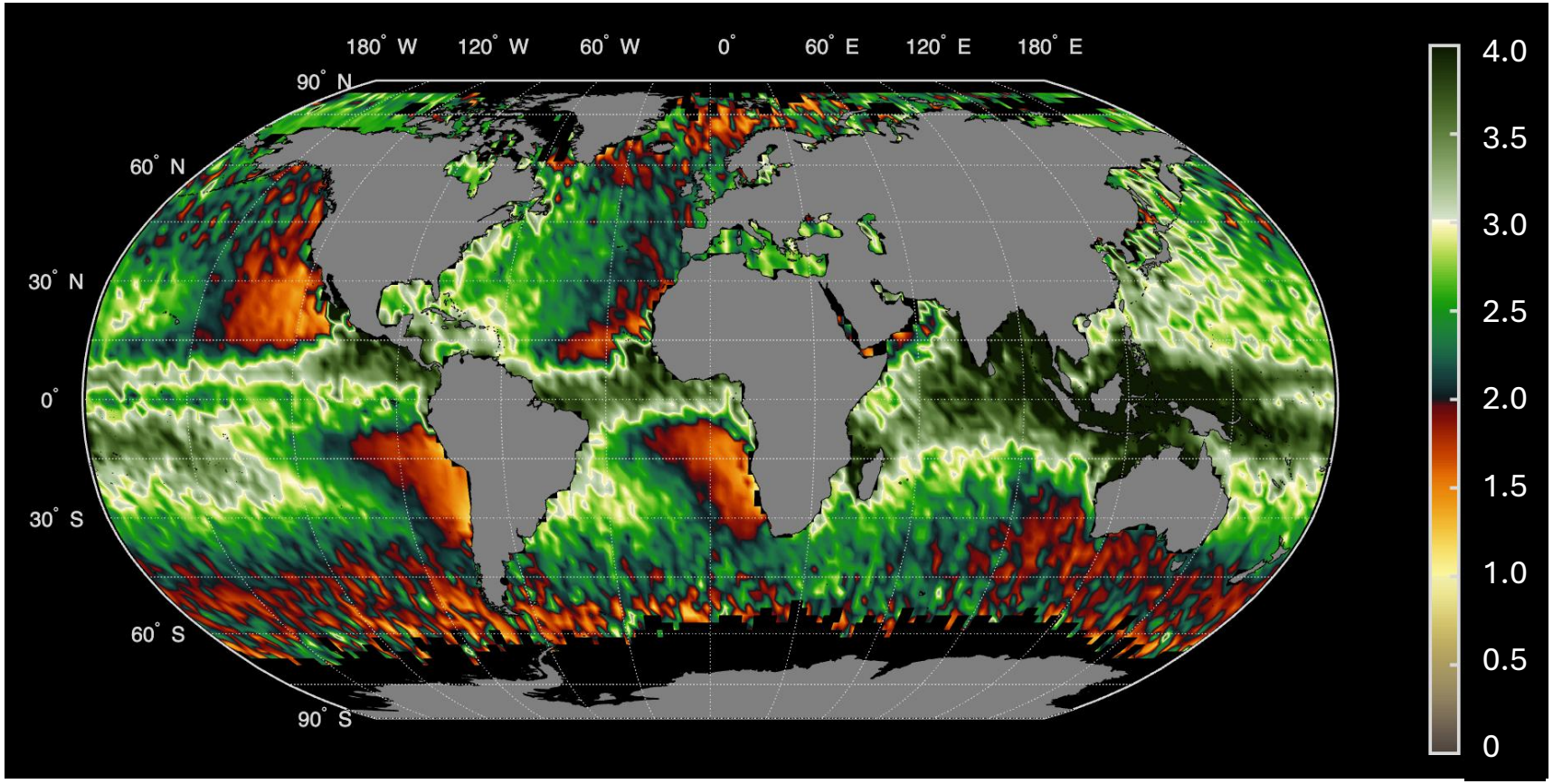
Total number concentration (N_T)

Rainfall rate (R) and rain water content (Q_R)

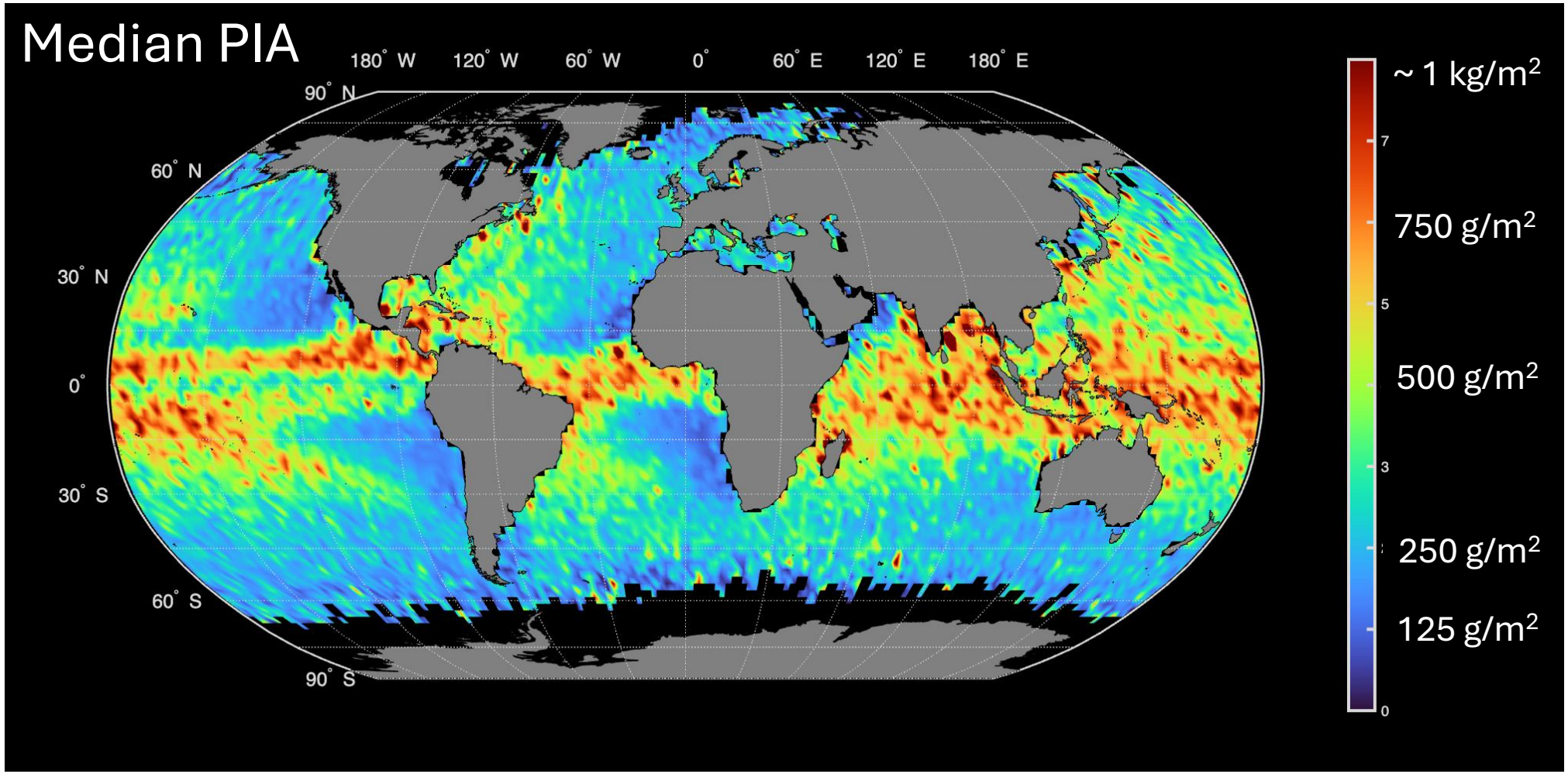
Warm Rain Observations – Cloud Top Height

- 1 year of observations
  - 12/24 – 11/25
- 250M echo detections
- Distinct shallow/warm cloud regimes:
  - Stratocumulus areas
  - Trade-cumulus
  - ITCZ

CPR Cloud Top Height (km)

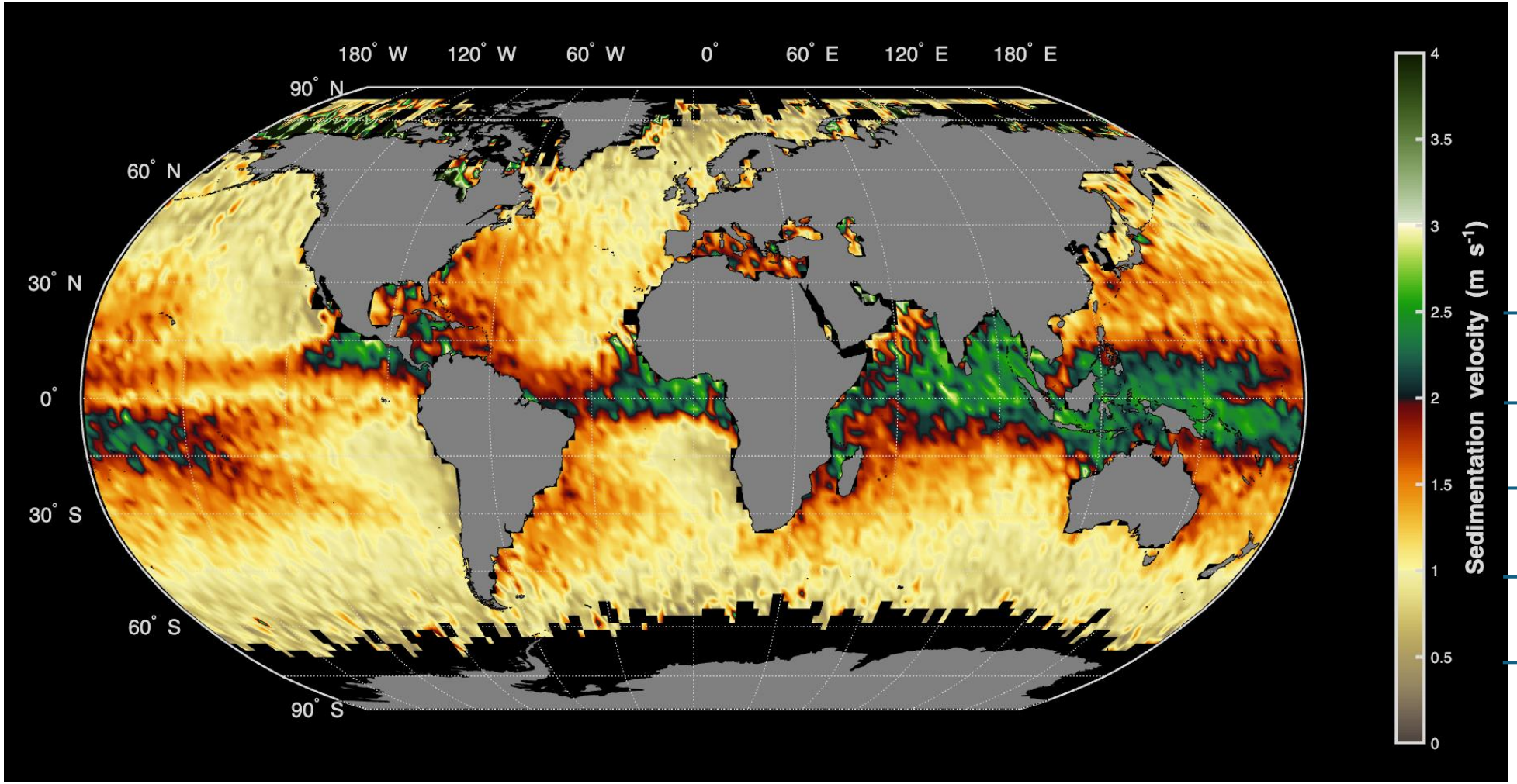


Warm Rain Observations – Path Integrated Attenuation



Sasikumar et al., 2025: doi.org/10.5194/egusphere-2025-3573

Climatology of Warm Rain Sedimentation velocity



Median Drop Volume Diameter (μm)

360 – 460

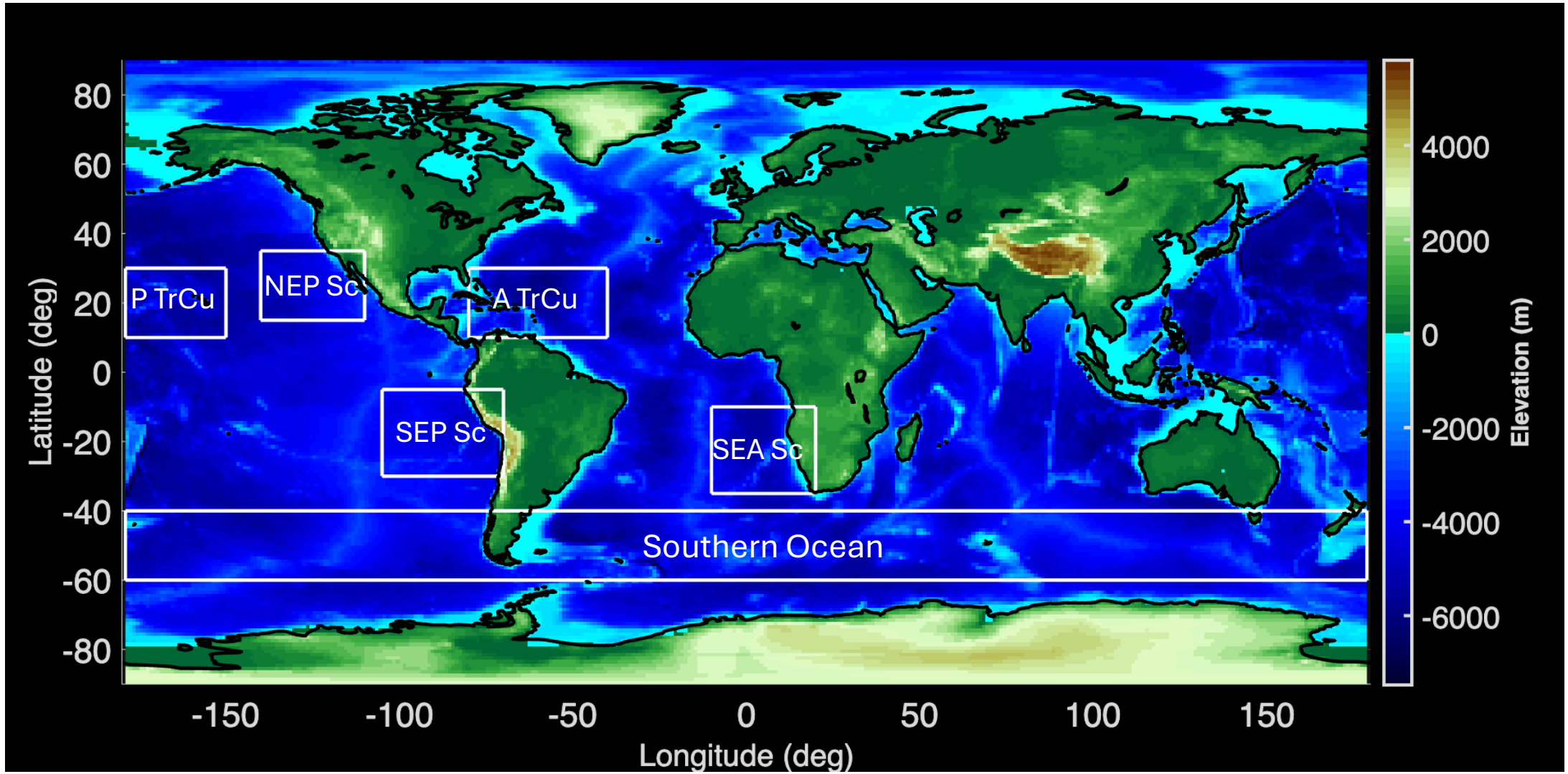
250 – 350

200 – 270

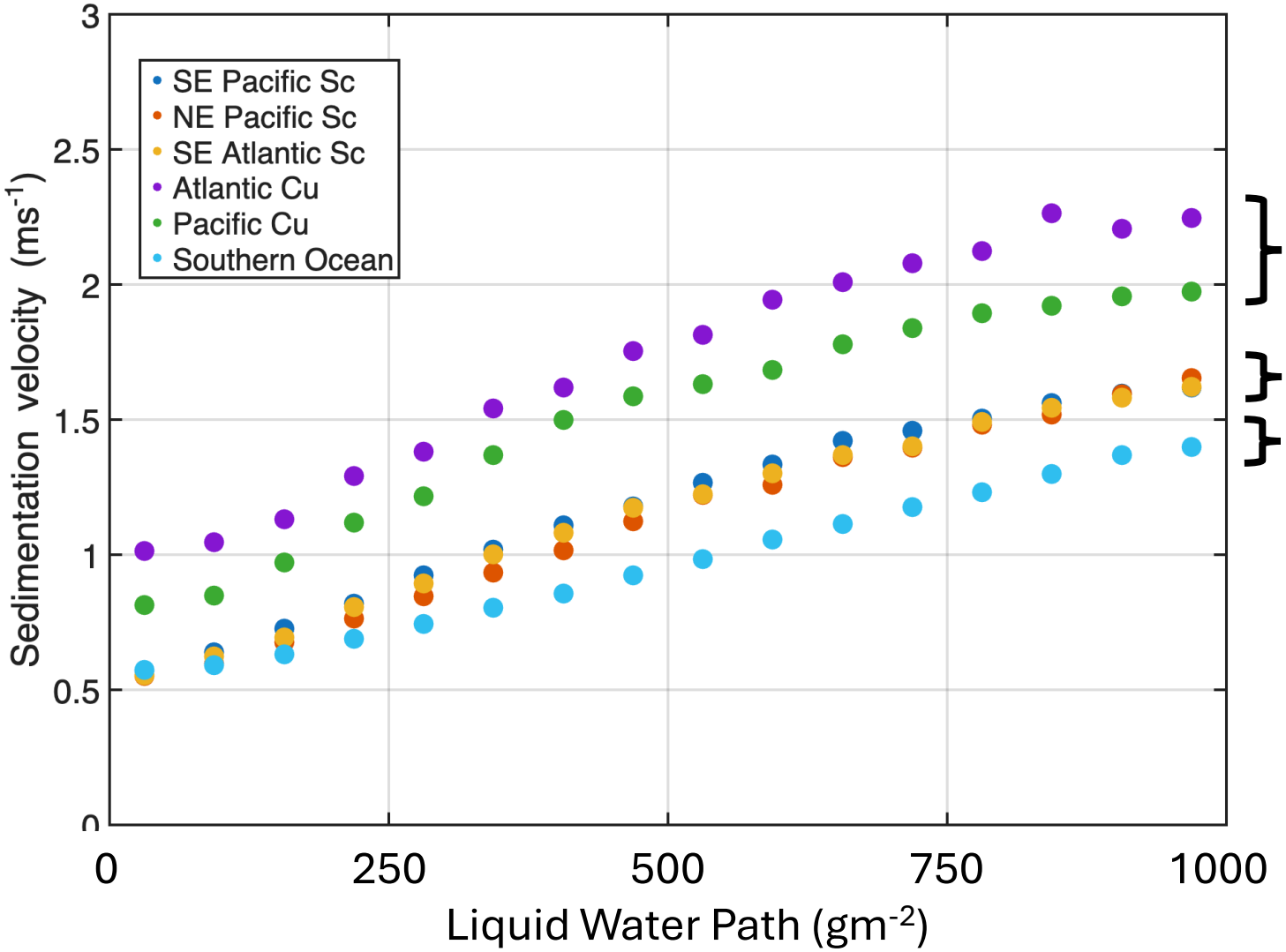
140 – 190

75 – 115

Regime-based warm rain analysis



Sedimentation Doppler Velocity [ms^{-1}]



Trade cumulus

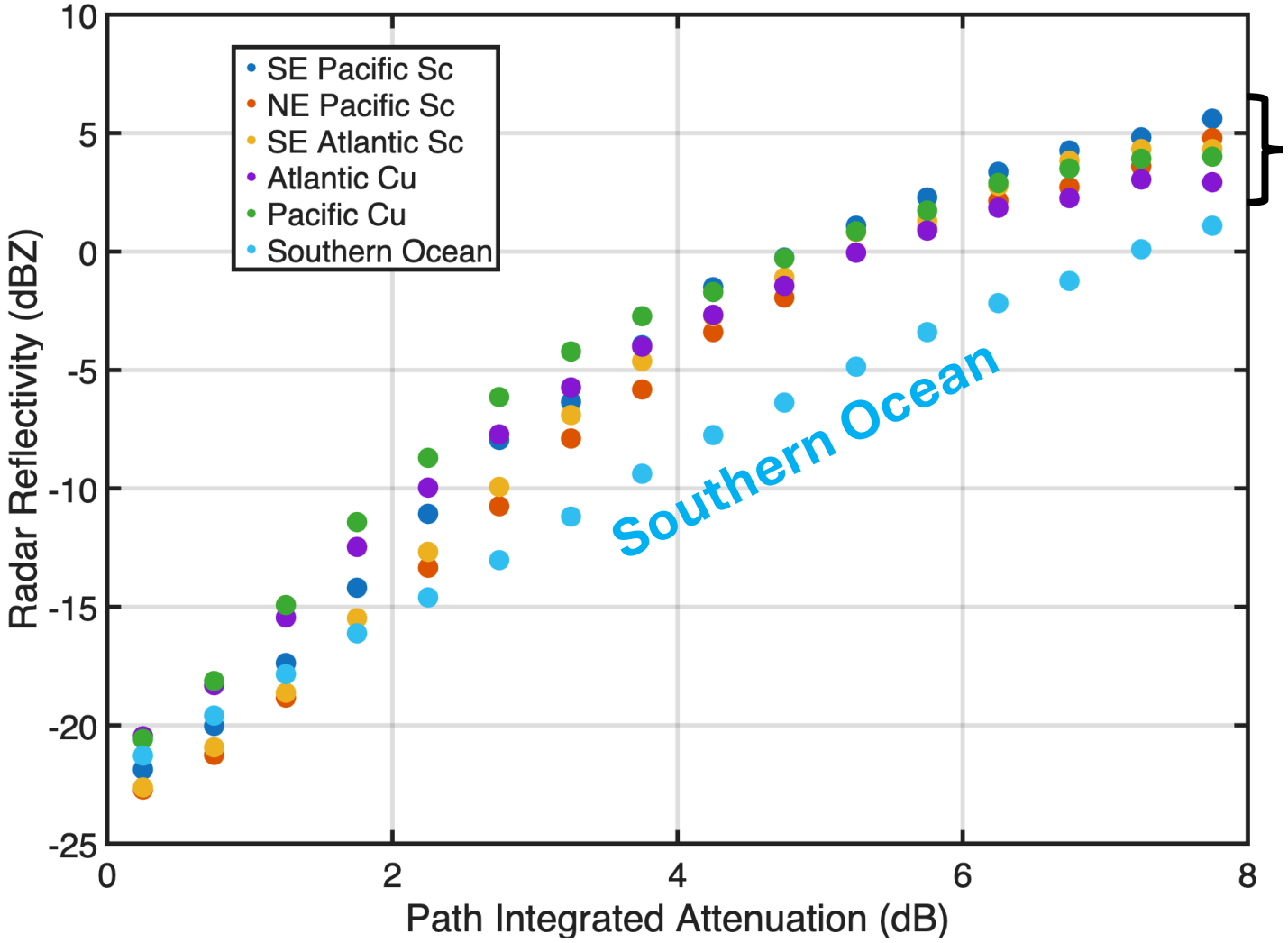
Stratocumulus

Southern Ocean

Large drizzle/raindrop size variability for the same LWP.

Dependency on the cloud regime

Radar reflectivity (dBZ)



Trade cumulus & Stratocumulus

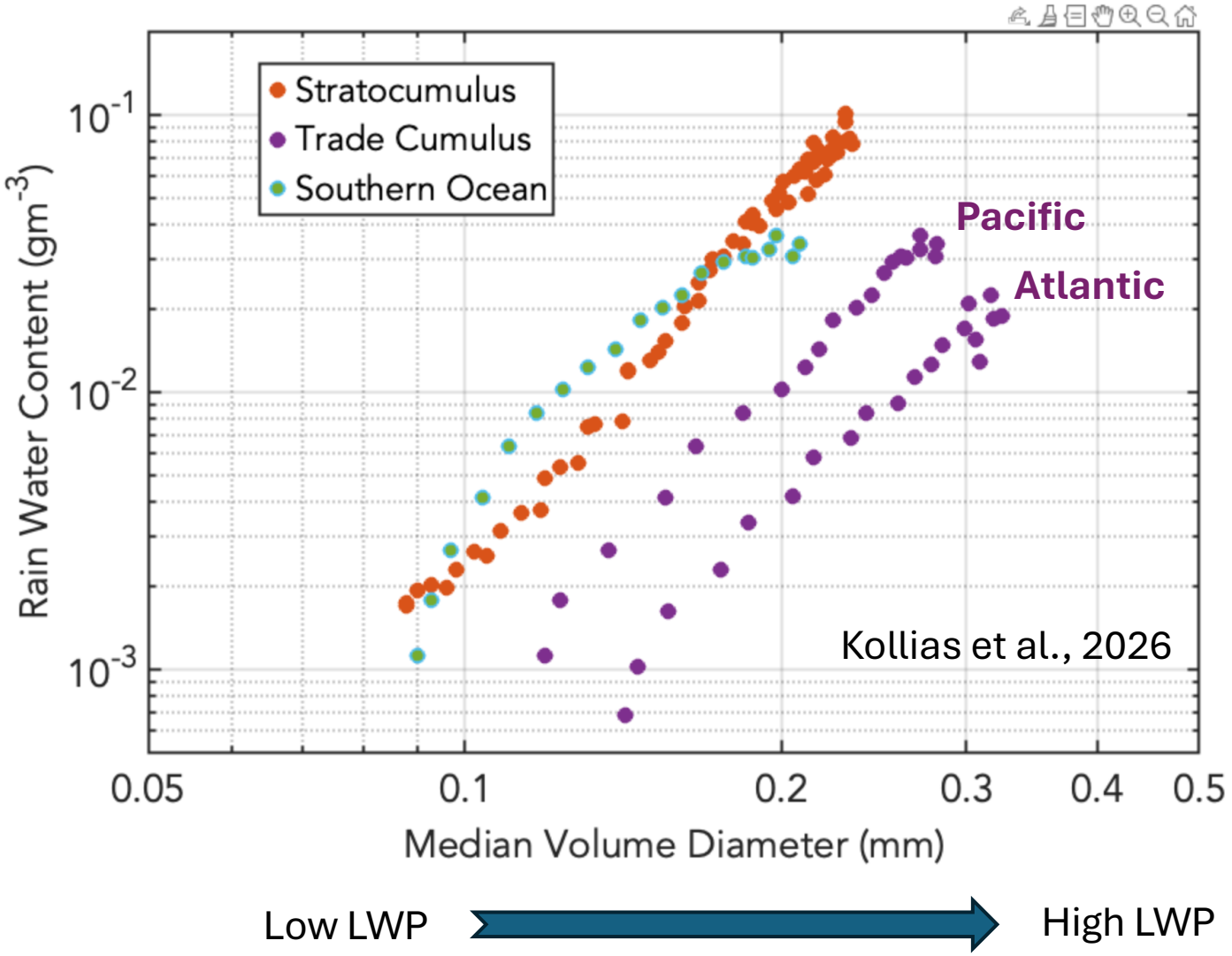
Similar radar reflectivity despite the differences in drop sizes

Warm rain: Mixing ratio vs size

Regime dependent mass – size relationships

Consistent warm rain microphysics across marine stratocumulus basins

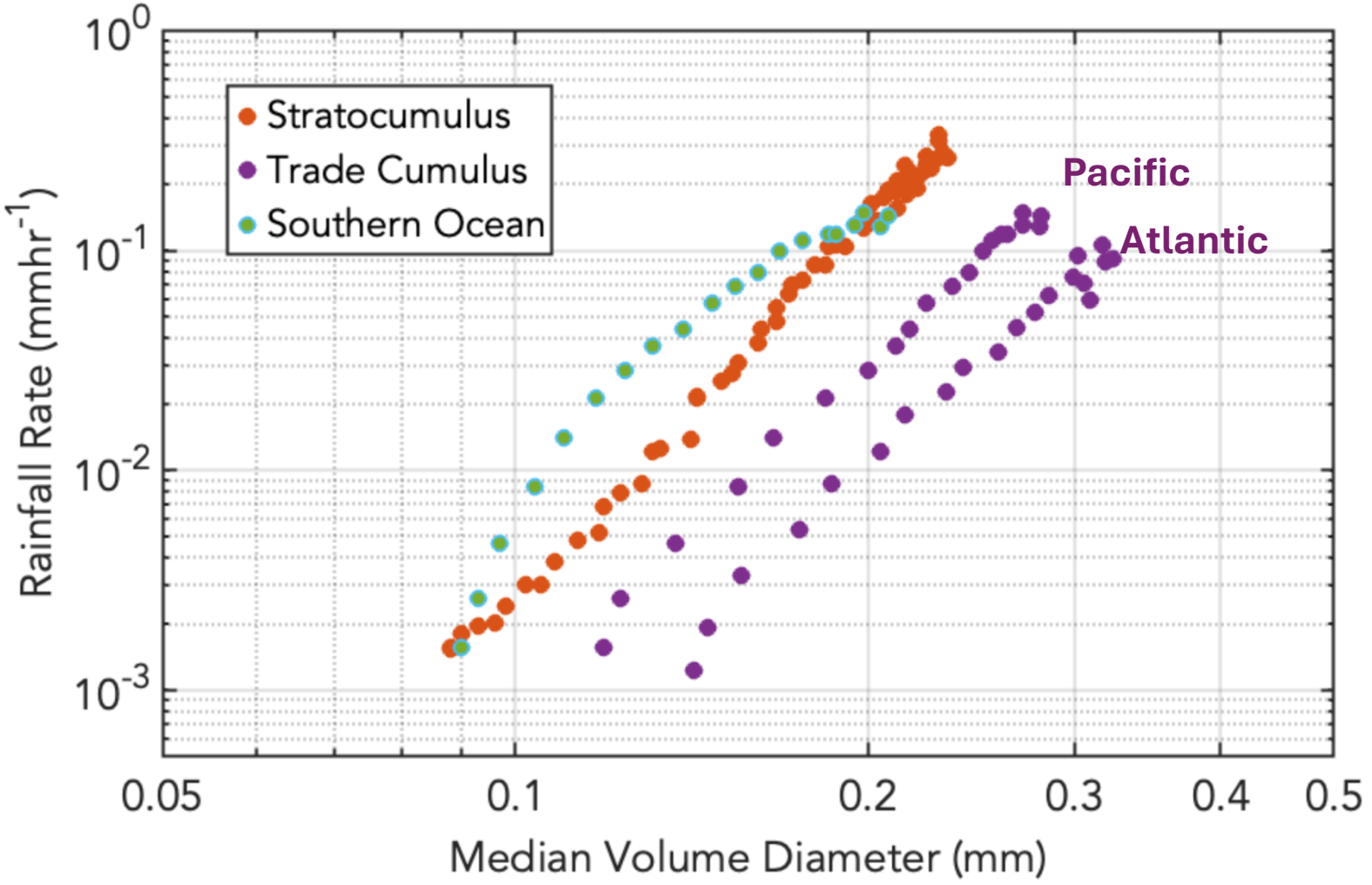
Large variability across trade-cumulus basins



Warm rain: Rainfall rate vs size

Rainfall rate is controlled by the drizzle number concentration

Implications for virga depth, BL energetics



Summary

The EarthCARE CPR combined radar reflectivity, Doppler velocity and PIA measurements are a game changer for the study of warm rain microphysics

Capability to detect precipitation at dBZ as low as -20. This is better performance than a surface disdrometer

First global climatology of drizzle and small raindrops sizes. Cumulus clouds produce larger size precipitating particles compared to stratocumulus for the same LWP.

Characterize regime dependent mass-size relationships in stratocumulus, trade-wind cumulus and the southern ocean

Information on virga depth and PBL energetics from the size and rainfall rate estimates.