Global Virga Precipitation Distribution Derived From Three Spaceborne Radars and Its Contribution to the False Radiometer Precipitation Detection

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Objective:

- Quantify virga occurrence, using TRMM PR, GPM DPR, and CloudSat CPR
- Quantify virga contribution to the false radiometer (TMI and GMI) precipitation detection

Datasets: (radar profile, and radiometer detection result)

Satellite Name	Sensor Name	Product name	version	parameters
TRMM	PR	2A25	version 7	
GPM	KuPR/KuPR	2ADPR	version 5	reflectivity profile, surface reflectivity
CloudSat	CPR	2B-GEOPROF	version 5	
TRMM	TMI	2A12	version 7	surface precipitation detection
GPM	GMI	2AGPROF	version 5	surface precipitation detection

Characteristics of TRMM PR, GPM DPR and CloudSat CPR

	TRMM PR	GPM KuPR/KaPR	CloudSat CPR
Frequency (GHz)	13.8	13.6/35.55	94.05
Minimum detection (dBZ)	17	12/12	-30
Horizontal resolution (nadir, km)	4.3[a]	5.2/5.2	1.4×1.8
Vertical resolution (m)	250	125/250	500
Spatial coverage	36°S-36°N	65°S-65°N	82°S-82°N
Temporal coverage	12/1997-04/2015	03/2014-	04/2006-04/2011[b]

- For PR and DPR, only nadir pixel is used
- We use the full record of TRMM data from 1997 to 2015. GPM data used in this study are from 2014 to 2017, and CloudSat data are from 2006 to 2011
- The much different minimum detection thresholds from these three radars lead to different virga percentages (more details later)

Virga precipitation definition:

- **PR**: near surface Z < 17 dBZ, while at least one Z value in the profile ≥17 dBZ
- **KuPR/KaPR**: similar to PR, except the threshold value being 12 dBZ
- **CPR**: near surface Z < -15 dBZ, while at least one Z value in the profile ≥ -15 dBZ & < 10 dBZ

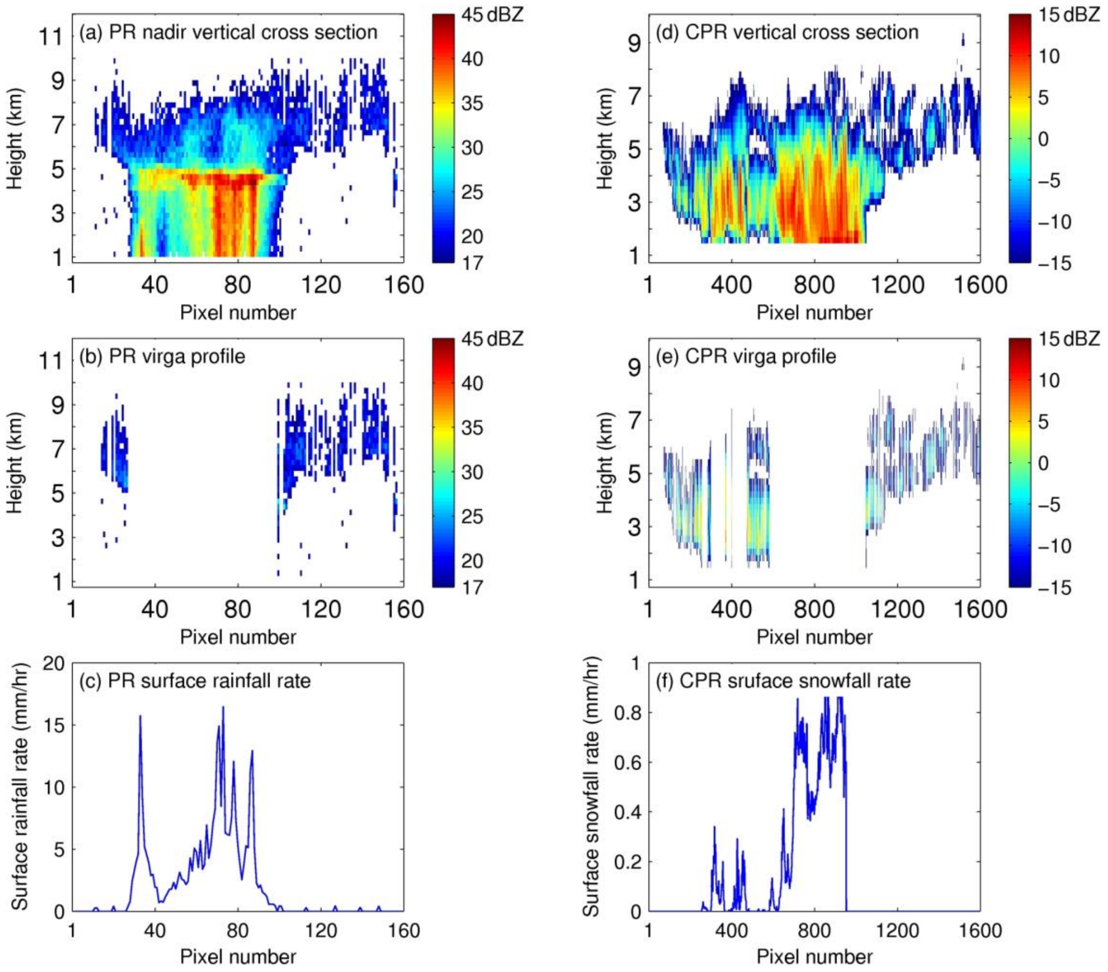
- For CPR, when there is a Z value in the profile > 10 dBZ, but near surface Z is < -15 dBZ, we consider this kind of profile as a "precipitating" profile due to strong attenuation. The 10 dBZ value is determined by collocated PR and CPR dataset

Uncertainties:

Underestimate virga events: spaceborne radar uses the near-surface bin as a proxy for surface precipitation, this study probably underestimates virga events due to the near-surface blind zone, whereby evaporation/ sublimation can occur between the near-surface bin height and the surface.

Overestimate virga events: the instantaneous satellite observation only provides a snapshot picture, while the hydrometers may fall to ground after the observation. In this perspective, this study may overestimate virga events under such circumstances.

Virga case from PR and CPR



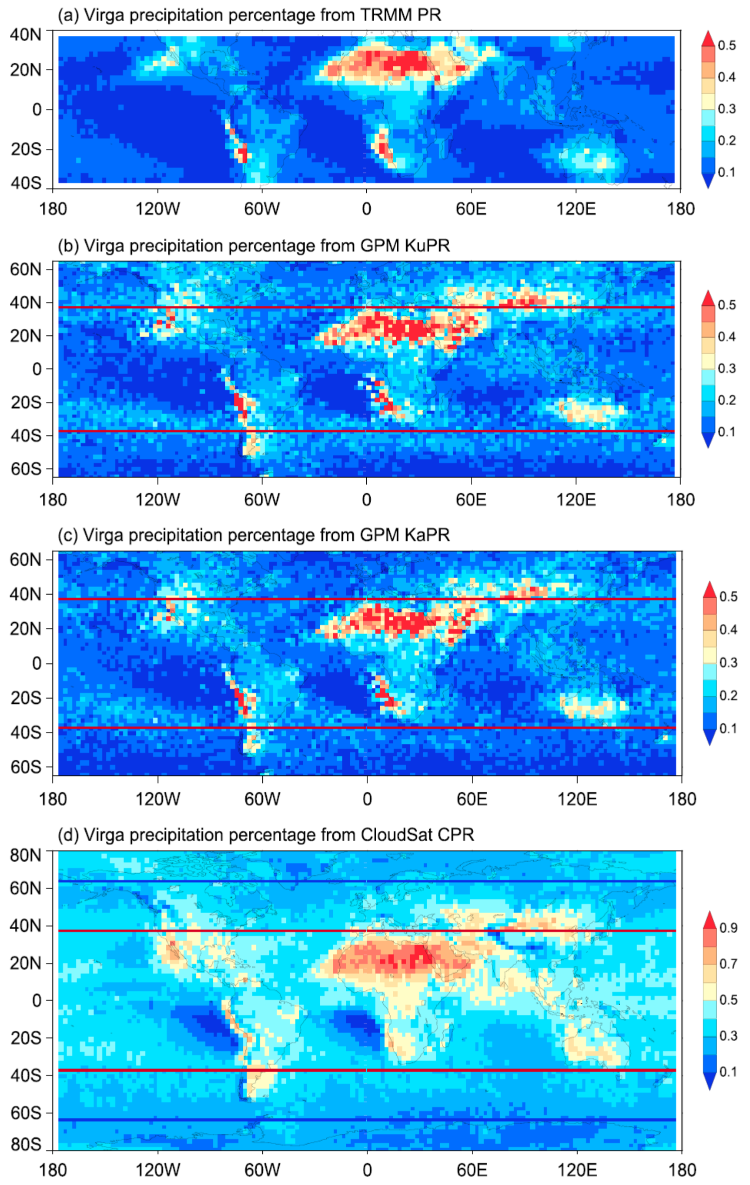
First column:

- nadir vertical cross section on 12/10/2002, over North Pacific (31.5N–33.5N,145E–153E)
- virga profiles
- surface rain rate

Second column:

- CPR vertical cross section on 20/09/2006, over Alaska and adjacent ocean (68N–78N, 100W–160W)
- Virga profiles
- Surface snowfall rate

Virga occurrence percentage



- **Virga precipitation occurrence percentage:** virga events divided by (virga event + precipitation events), in each 2.5 degree grid box

- **Why not the absolute virga number**: because these three satellites (TRMM, GPM, and CloudSat) have more samples in the higher latitudes due to orbital characteristics.

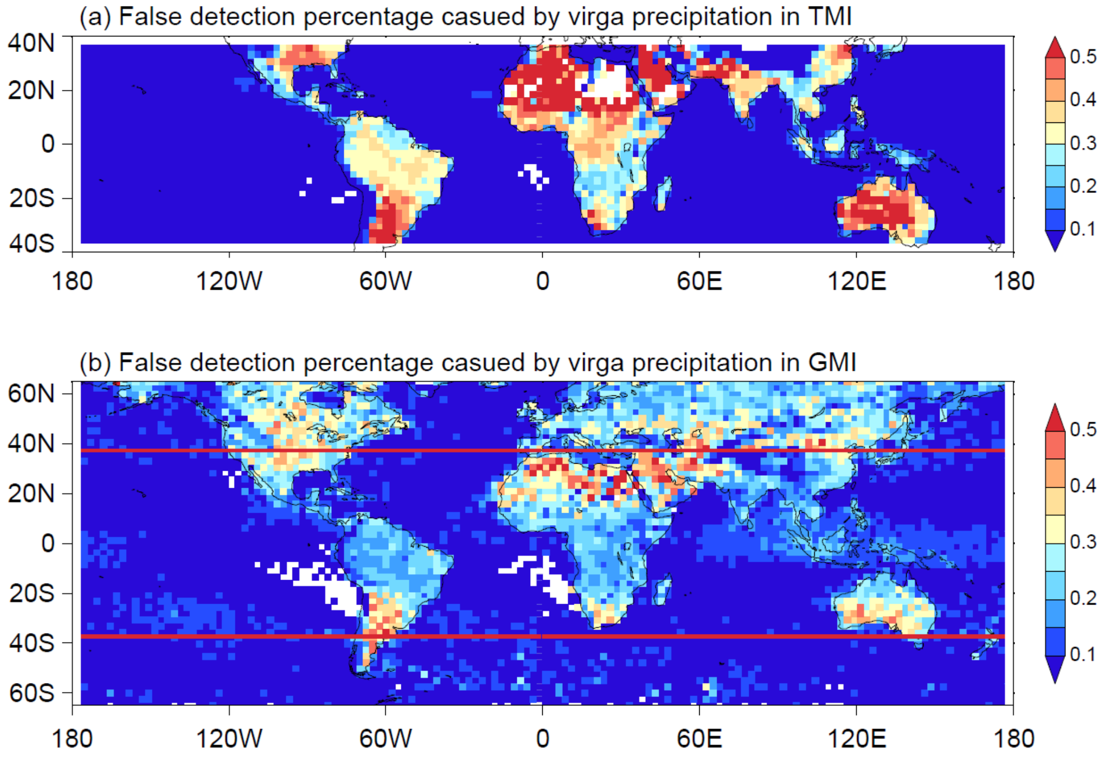
- Red and blue lines represent TRMM and GPM covered region boundaries (~36S, ~36N, ~65S, and ~65N).

- **Virga primarily occurs over land**, especially over the arid regions.

- **The virga occurrence percentage is over 30%** in arid regions based on PR, KuPR, and KaPR observations, with the largest virga percentage over the Sahara Desert region (> 50%).

- **The CPR virga percentage is almost doubled** due to much better detection sensitivity.

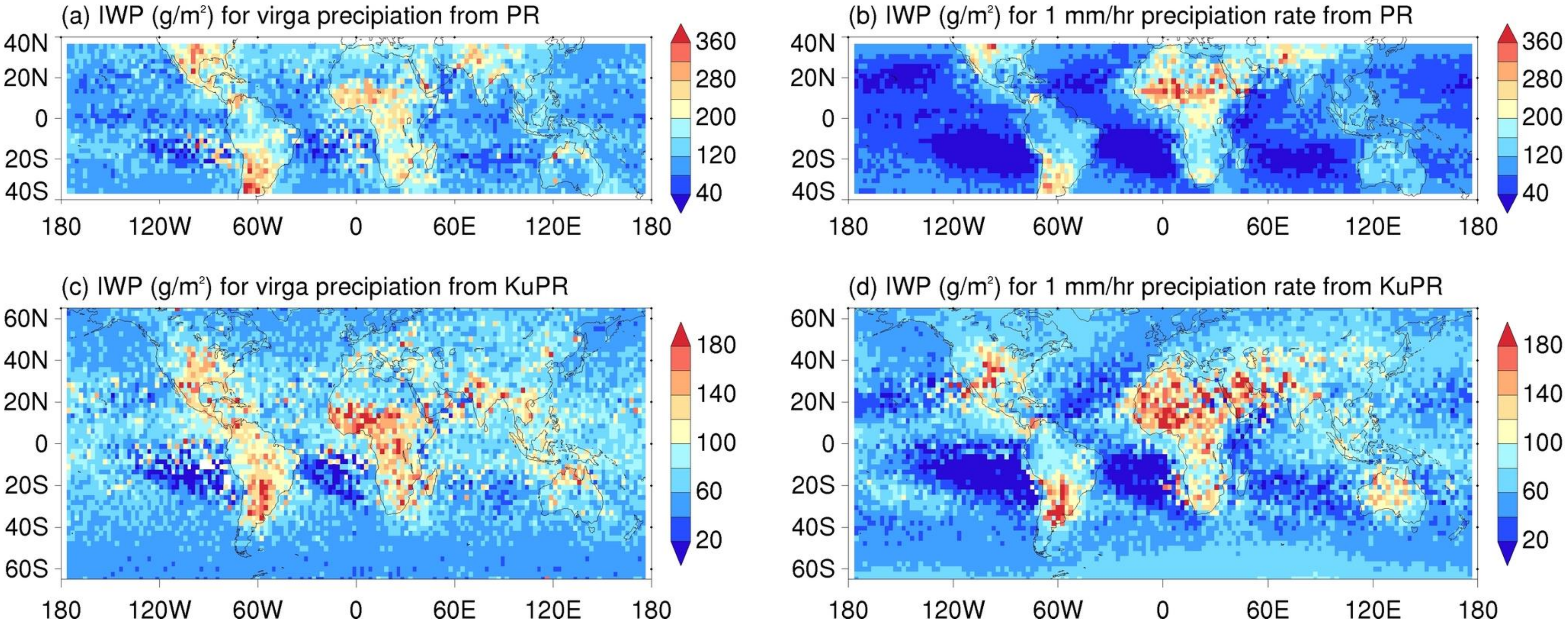
Virga contribution to false radiometer precipitation detection



- False detection percentage caused by virga: (1) find the total false detection pixel number (2) find which pixel is associated with a virga profile
- TMI detection results**: over half of the false detection is caused by the virga precipitation over arid regions** (e.g., Sahara desert, Arabian Peninsula, and deserts of Australia).
- GMI detection result: Over the arid regions, the false detection caused by virga is still large at ~30%.

- **Certain land surfaces (e.g., desert) may have a similar scattering signature as precipitation**. There are extensive studies in the literature to screen out these land surfaces to avoid possible false precipitation detection
- This study implies that **virga is an equally important factor for the false precipitation detection over the arid regions**

Why virga is falsely identified as surface precipitation



- **Because virga has similar amount of water paths, compared with light precipitation** (e.g., 1 mm/hr), and TB directly reflect the water paths' influence, not surface rain rate.

Summary:

- The virga occurrence percentage is over 30% (50%) by both PR and DPR (CPR) over arid regions
- The virga accounts for ~50% (30%) of false precipitation detection by TMI (GMI) over arid regions

Reference:
Wang, Y., You, Y., & Kulie, M. (2018). Global Virga Precipitation Distribution Derived From Three Spaceborne Radars and Its Contribution to the False Radiometer Precipitation Detection. *Geophys Res Lett.*, 45(9), 4446-4455.