An Evaluation of the GPROF V7 Cloud-Radiation Database in EOF space

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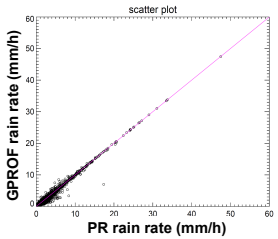
Description of GPROF V7 Database

- GPROF 2010 begins with the operational TRMM PR algorithm and adjusts its solution as little as possible while striving to simultaneously match the radiometer observations.
- Where the TRMM PR indicates no rain, an optimal estimation procedure using TMI radiances is used to retrieve non-raining parameters.
- Within raining fields of view, cloud-resolving model outputs are matched to the liquid and frozen hydrometeor profiles retrieved by the PR.
- The Cloud resolving models act primarily to constrain parameters such as cloud water and ice that are not detected directly by the PR.
- The profiles constructed in this manner are used to compute TBs that are then compared directly to coincident observations.
- The database is generated only in the central 11 pixels of the PR radar scan, and the rain adjustment is performed independently for distinct SST and TPW values.
- In this manner, the GPROF-V7-DB has been constructed having data sets of TMI TBs, corresponding rain and PR rain.



Generation of Radiance Indices

- The attenuation index (P) is a normalized polarization difference.
- The scattering index (S) represents volume scattering associated with frozen precipitation aloft (Petty, 1994).
- Modified radiance indices (Seo et al., 2007)

$$P_m = 100(1 - P) \text{ and } S_m = -S$$

- All TMI TBs in the GPROF V7 DB are converted to the modified radiance indices.

Multivariate Relations of Attenuation and Scattering Indices

- A column vector, I, containing four attenuation indices and a scattering index, is defined as

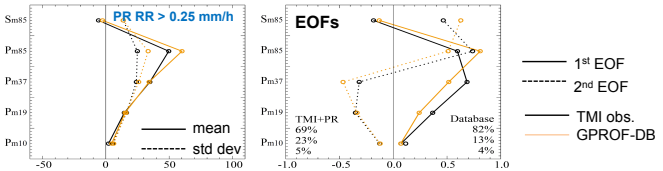
$$\mathbf{I} = \begin{bmatrix} P_{m10} \\ P_{m19} \\ P_{m37} \\ P_{m85} \\ S_{m85} \end{bmatrix}$$

- These anomalies are then expressed with respect to EOFs of each observational or simulation data set such that

$$\mathbf{I}_i' = \sum_{j=1}^{N} \alpha_{i,j}\mathbf{e}_j$$

where $\alpha_{i,j}$ is the amplitude associated with the j^{th} EOF, $\mathbf{e}_j$, for the ith radiance index vector and N is the number of EOFs (Biggerstaff and Seo, 2010).

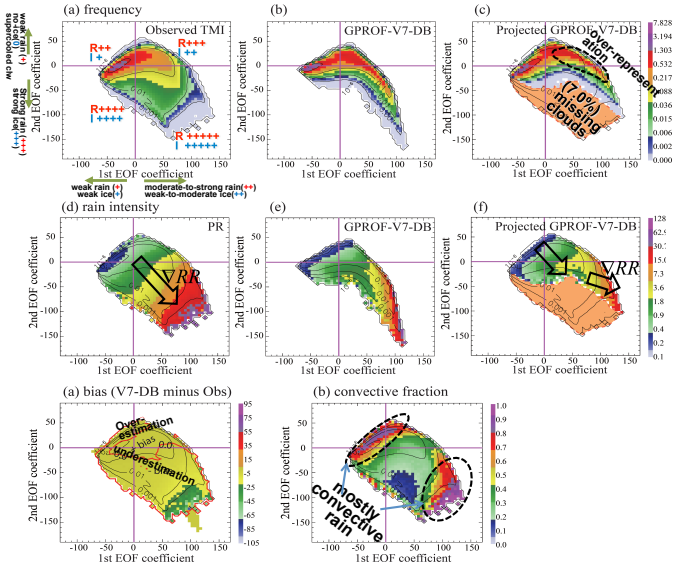
What does EOF represent?



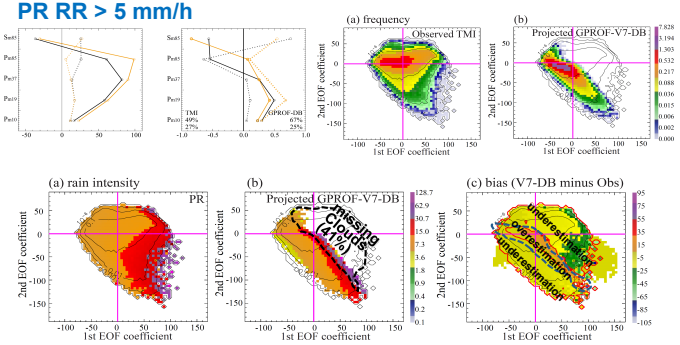
1st EOF	$\alpha_{i,1}>0$	moderate-to-strong rain & weak-to-moderate ice layer
	$\alpha_{i,1}<0$	weak rain & weak ice layer
2nd EOF	$\alpha_{i,2}>0$	weak rain & no-ice layer, possibly supercooled clw
	$\alpha_{i,2}<0$	strong rain & strong ice layer

The Manifolds of EOF coefficients

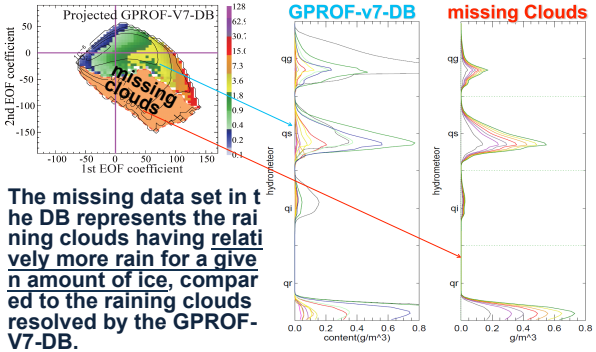
PR RR > 0.25 mm/h



PR RR > 5 mm/h



What types of clouds are missing in the DB?



The missing data set in the DB represents the raining clouds having relatively more rain for a given amount of ice, compared to the raining clouds resolved by the GPROF-V7-DB.

Summary

- ❑ In terms of rain intensity, the GPROF-V7-DB agrees well with the PR.
- ❑ The first and second EOF structures of TBs represent certain types of raining clouds:
  - 1st EOF: more rain with less ice aloft (or less rain with less ice aloft)
  - 2nd EOF: less rain with no ice aloft (or more rain with more ice aloft)
- ❑ Overall, there is a good agreement in the frequency distribution of EOF amplitudes between the observed and GPROF-V7-DB TMI TBs.
- ❑ Nevertheless, the GPROF-V7-DB shows missing raining clouds which correspond to about 7% of total raining clouds.
- ❑ For PR RR > 5 mm/h, the GPROF-V7-DB have missing clouds of 41% compared to the observations.
- ❑ Those missing clouds are likely raining clouds having relatively more rain for a given amount of ice.

References

Biggerstaff, M.I. and Seo, E.K. (2010), An EOF-Based Comparison and evaluation of simulated passive microwave signatures to observations over tropical oceans. Journal of Geophysical Research, 115, doi:10.1029/2009JD013029.

Petty, G. W. (1994), Physical retrievals of over-ocean rain rate from multichannel microwave imagery. Part II: Algorithm Implementation, Meteorol. Atmos. Phys., 54, 101–121.

Seo, E.-K., B.-J. Sohn, and G. Liu (2007b), How TRMM precipitation radar and microwave imager retrieved rain rates differ, Geophys. Res. Lett., 34, L24803, doi:10.1029/2007GL032331.

Acknowledgement

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