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# Vertical Profiling of Precipitation with Passive Microwaves over Mid-Latitudes


Z.S. Haddad, K.-W. Park and S.L. Durden

Jet Propulsion Laboratory

California Institute of Technology


Contents:

1) Making optimal use of space-borne radar (TRMM, GPM)
2) How much vertical variability does rainfall exhibit anyway?
3) What can we do about the remaining ambiguities? (Bayesian approach)
4) 5 cases: Mediterranean, Sea of Japan, Eastern Atlantic, Western Atlantic, Eastern Pacific (Northern Hemisphere)

## 1) Making optimal use of space-borne radar (TRMM, GPM):

⇒ Use joint radar+radiometer swath to "teach" radiometer how to retrieve the vertical structure

This assumes that the radar tells the truth, the whole truth

It also assumes that the radiometer measurements are highly correlated with the vertical structure

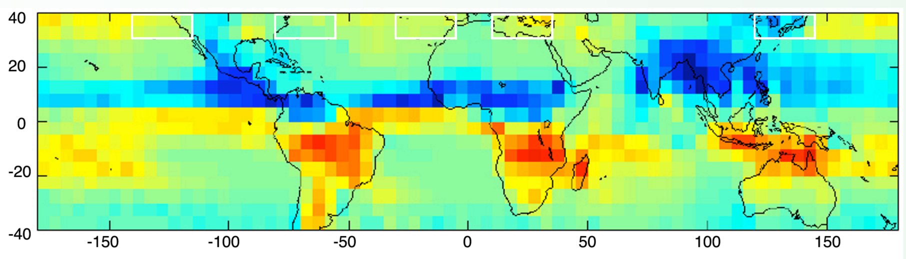
⇒ Must characterize the "amount" of structure,

⇒ and its correlation with the radiometer measurements

## 2) How much vertical variability does rainfall exhibit anyway?

Data: TRMM radar retrievals January-August 2007

Principal Component decomposition of log(R) (16x1 vector)




Eigenvalues:

| "Sea of Japan" | | "Mediterranean" | | "Eastern Atlantic" | | "Western Atlantic" | | "Eastern Pacific" | |
|---|---|---|---|---|---|---|---|---|---|
| 51.43 | 90.9% | 36.12 | 78.7% | 19.33 | 82.2% | 52.37 | 90.4% | 14.30 | 80.7% |
| 3.34 | 5.9% | 6.31 | 13.7% | 2.58 | 10.5% | 3.64 | 6.3% | 2.06 | 11.6% |
| 0.89 | 1.6% | 1.77 | 3.9% | 0.83 | 3.5% | 0.96 | 1.7% | 0.68 | 3.9% |
| 0.26 | 0.5% | 0.57 | 1.2% | 0.24 | 1.0% | 0.27 | 0.5% | 0.23 | 1.3% |
| etc | | etc | | etc | | etc | | etc | |

⇒ **Two cases:** **Mediterranean-like** **or** **monsoon-like**

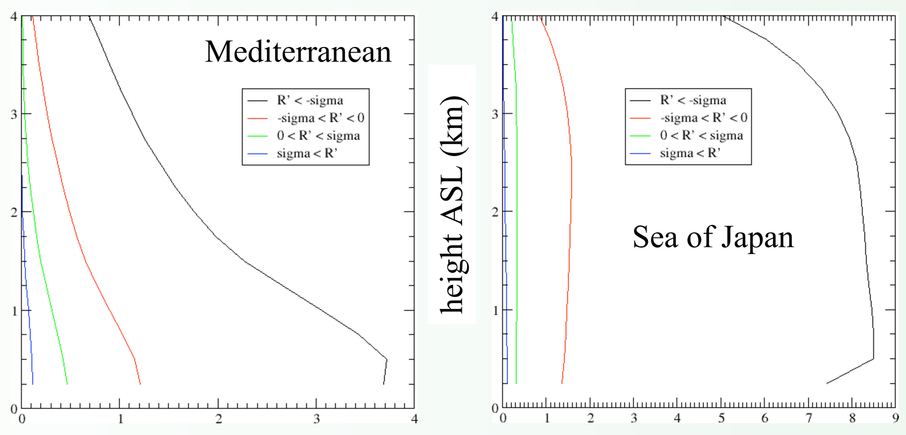
Average profiles whose first Principal Component is

one-sigma-or-more below the mean,

within-one-sigma-by-default from the mean,

within-one-sigma-by-excess from the mean,

and one-sigma-or-more above the mean




⇒ Try to use the 9 passive microwave radiances to estimate the first 3 rain principal components

- Would capture > 92% of variability
- Canonically sets the "vertical resolution" of the estimates
- Must have simultaneous radar/passive-microwave core
  (e.g. TRMM, GPM) – accuracy depends on core accuracy and representativity
- Quantify uncertainty in estimates

⇒ Bayesian

## 3) What can we do about the remaining ambiguities? (Bayesian approach)

What is "Bayesian"?

Given

instantaneous noisy measurements (passive radiometers),

and a priori joint statistics of

rain variables & measurements,

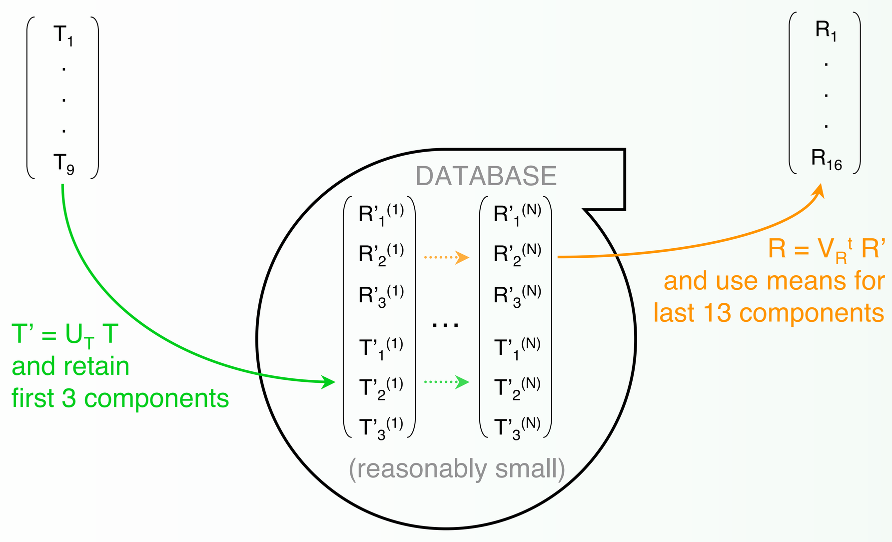
make unbiased estimate of variables and "correlations":

$$E\{\text{rain variable} \mid \text{measurements}\} = \Sigma_T \text{ variable } e^{-\text{dist}(\text{measurements},T)}$$

Why Bayesian is good (especially when measurements are few):

- minimize bias and residual error
- QUANTIFY THE UNCERTAINTY
- allow incorporation of additional data in future

On-line: Measure T's and estimate R's




## 4) (How well) does it work?

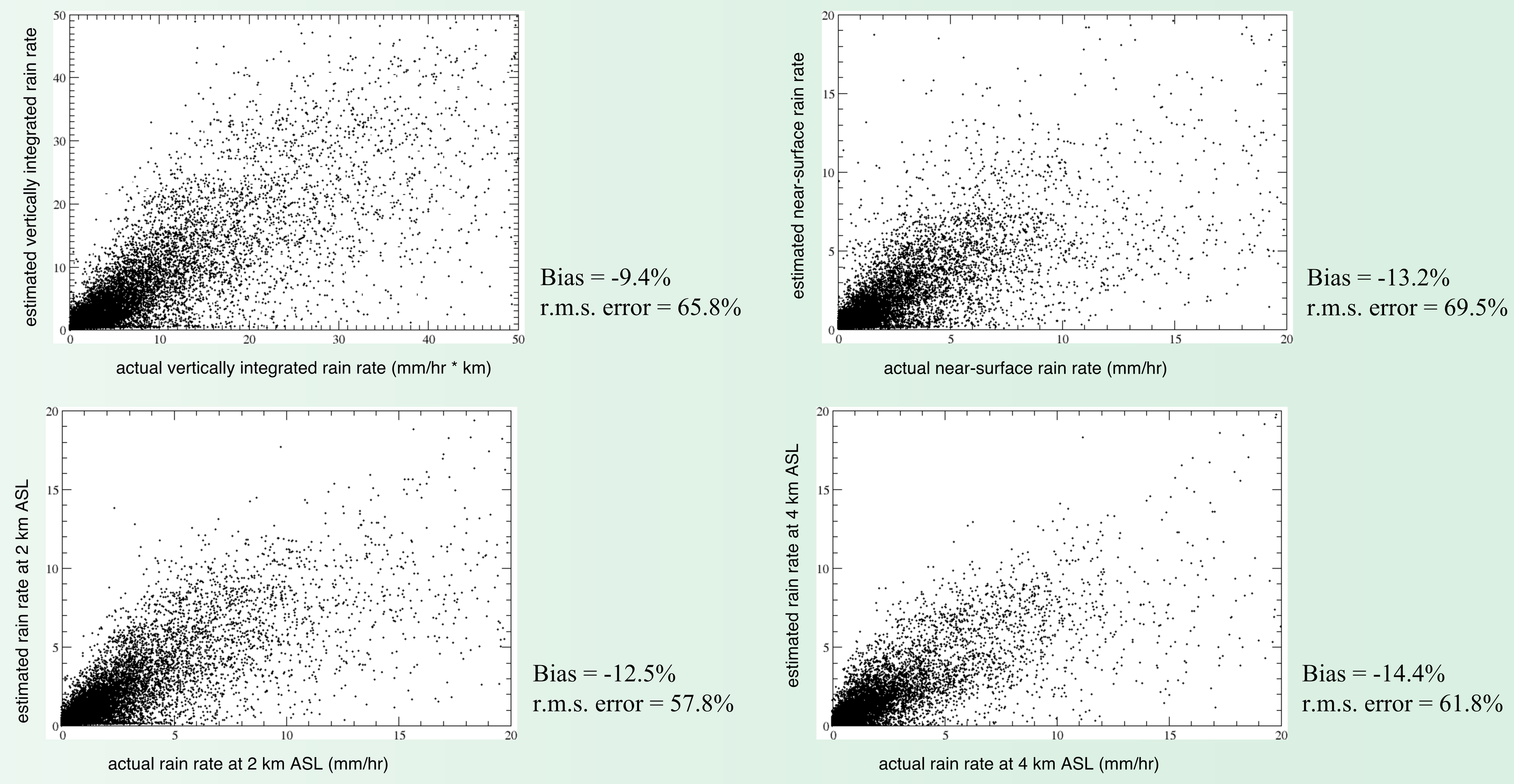
Applied the procedure diagnostically:

1. gathered core data for large granules during time period,
2. built the database,
3. then retrieved for other granules

Apply separately in each region, and compile statistics

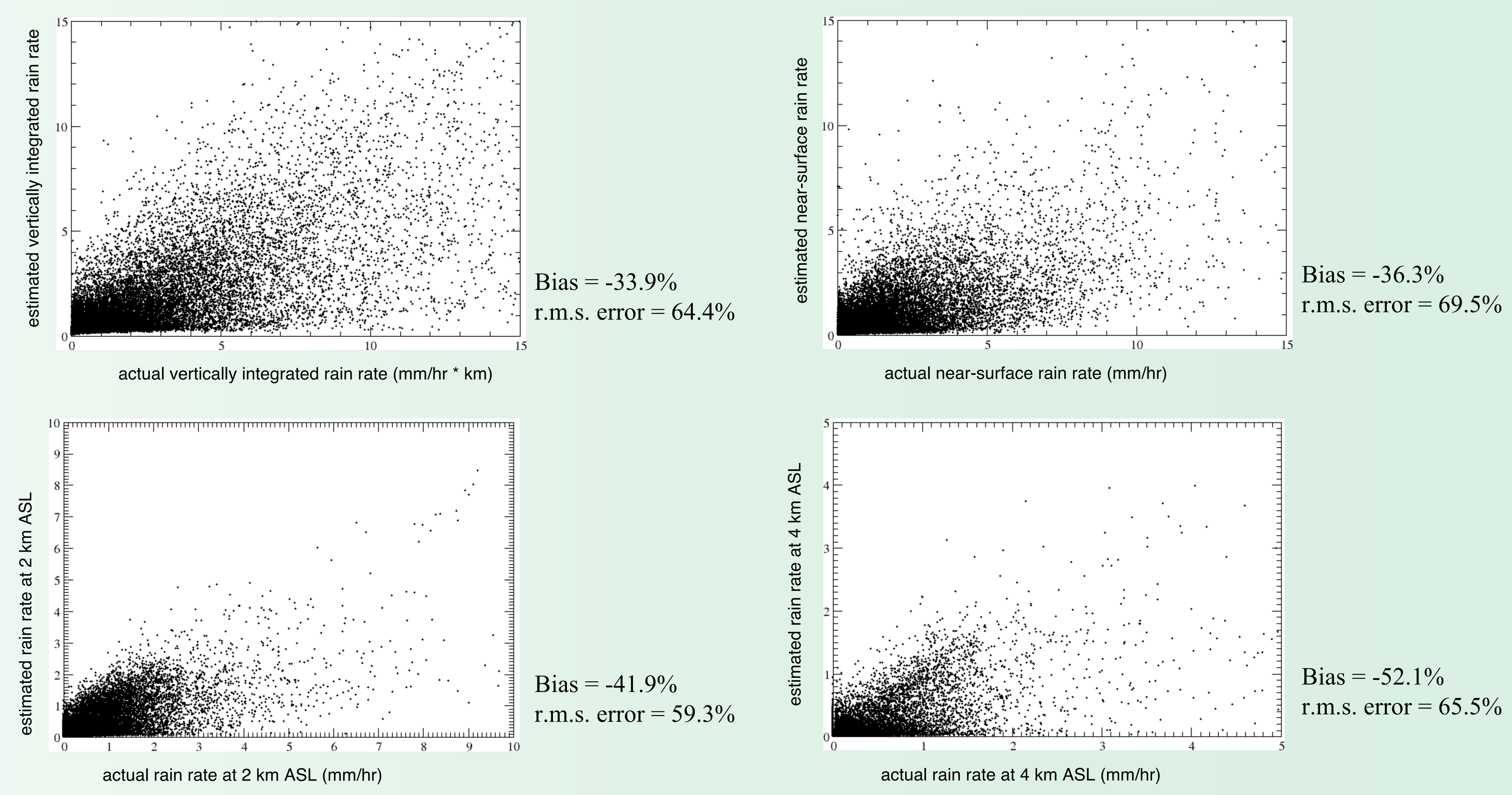
(Also, tested performance of one region's database on retrievals in another region)

Sea of Japan:



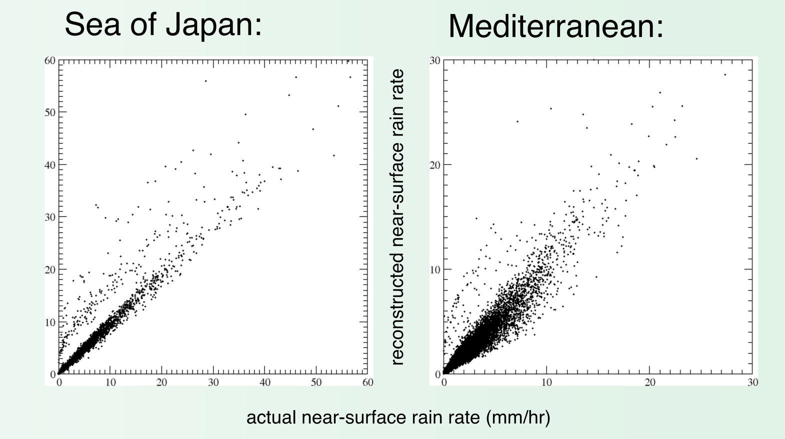

⇒ **Very encouraging!**

Mediterranean:

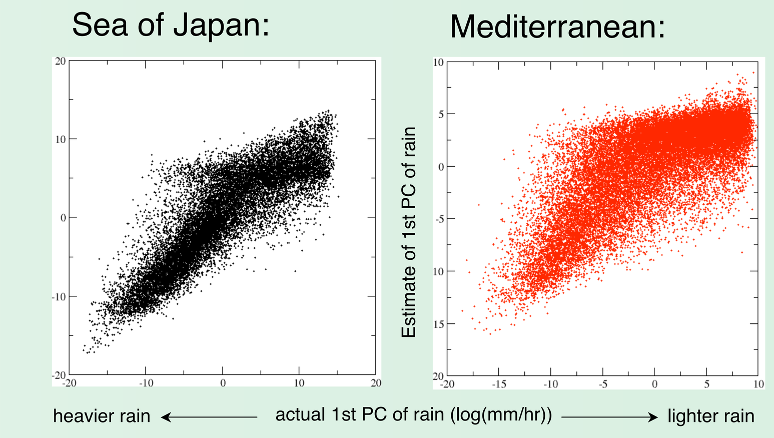



### Why is the performance in the Mediterranean so much worse?

How good is the reconstruction from 3 principal components?




How good is the principal component estimation?



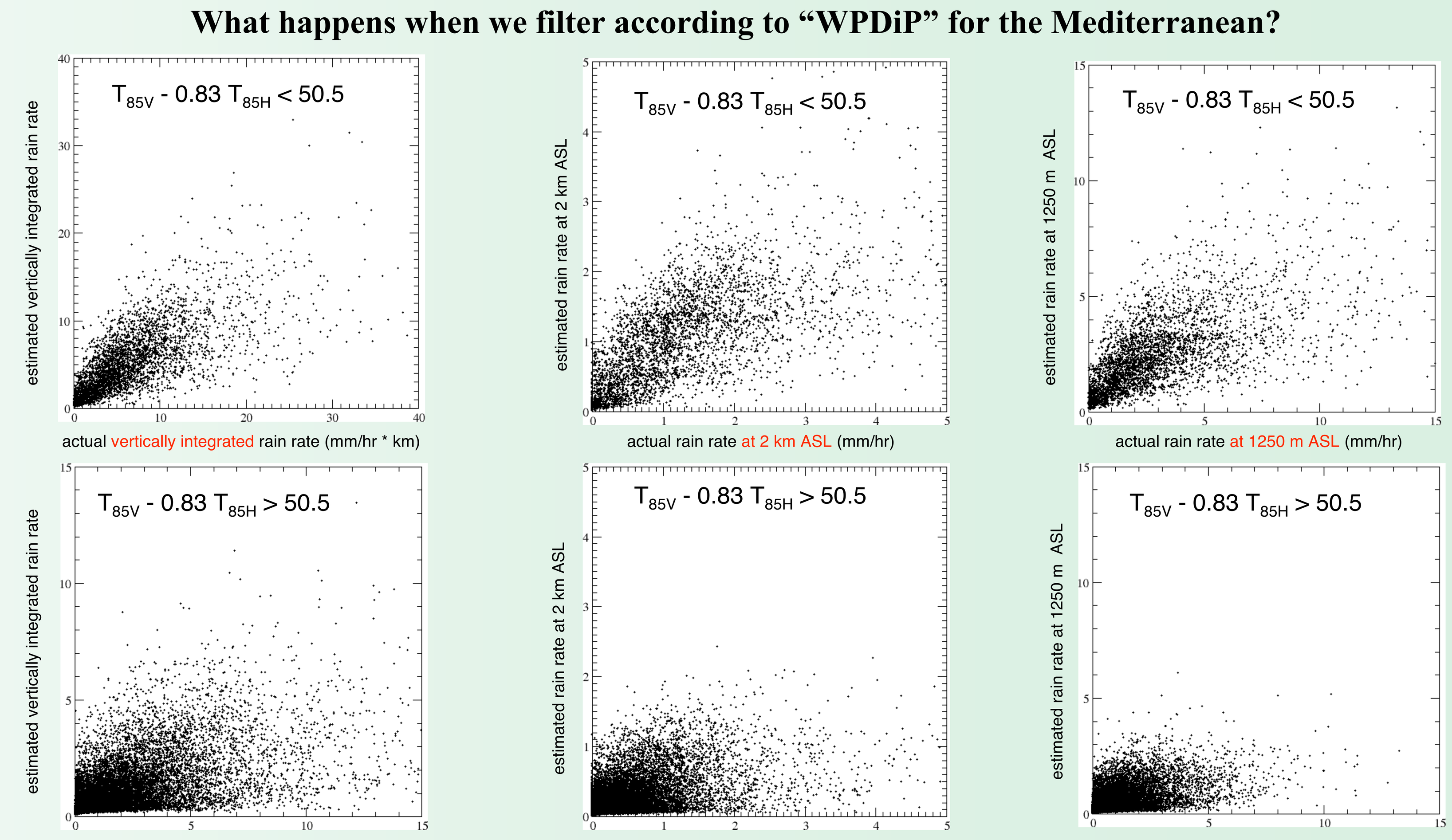

### How different are the principal components of T's?

| | Sea of Japan: $T_1'$ | $T_2'$ | Mediterranean: $T_1'$ | $T_2'$ |
|---|---|---|---|---|
| 10V: | 0.241 | -0.141 | 0.125 | -0.161 |
| 10H: | 0.440 | -0.249 | 0.224 | -0.288 |
| 19V: | 0.304 | 0.043 | 0.262 | -0.126 |
| 19H: | 0.572 | 0.055 | 0.497 | -0.265 |
| 37V: | 0.213 | 0.264 | 0.304 | 0.057 |
| 37H: | 0.491 | 0.410 | 0.658 | -0.009 |
| 85V: | -0.167 | 0.503 | 0.046 | 0.554 |
| 85H: | -0.114 | 0.650 | 0.302 | 0.704 |
| | emission | scattering | Sea-surface effect | |

scattering from precipitation is largely unpolarized, so …

⇒ Try using a "**W**eighted **P**olarization **D**ifference **i**n **P**recipitation" discriminant to sort data:

### What happens when we filter according to "WPDiP" for the Mediterranean?




## Conclusions:

- Vertical profiling capability can require characterizing the radiometrically cold (and highly polarized) sea surface,
- particularly in Mediterranean-like regions where the precipitating area may not extend over the entire radiometer field of view.
- However, in general, we can successfully estimate vertical profiles (with quantifiable - and small - bias) or flag measured $T_b$ vector as mixed with "open" sea surface requiring quantification, if representative radar samples are consistently available