Impact of non-uniform beam filling on spaceborne cloud and precipitation radar retrieval algorithms

Jet Propulsion Laboratory
California Institute of Technology

Simone Tanelli, G.F. Sacco, S.L.Durden, Z.S.Haddad

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA;

Acknowledging contributions by: R. Meneghini (NASA-GSFC), D. Short (NASA-GSFC & NICT)

© 2012, California Institute of Technology. Government sponsorship acknowledged.

Outline

Jet Propulsion Laboratory
California Institute of Technology

① Non-Uniform Beam Filling Impact

② Experimental Evidence

③ Theoretical Framework

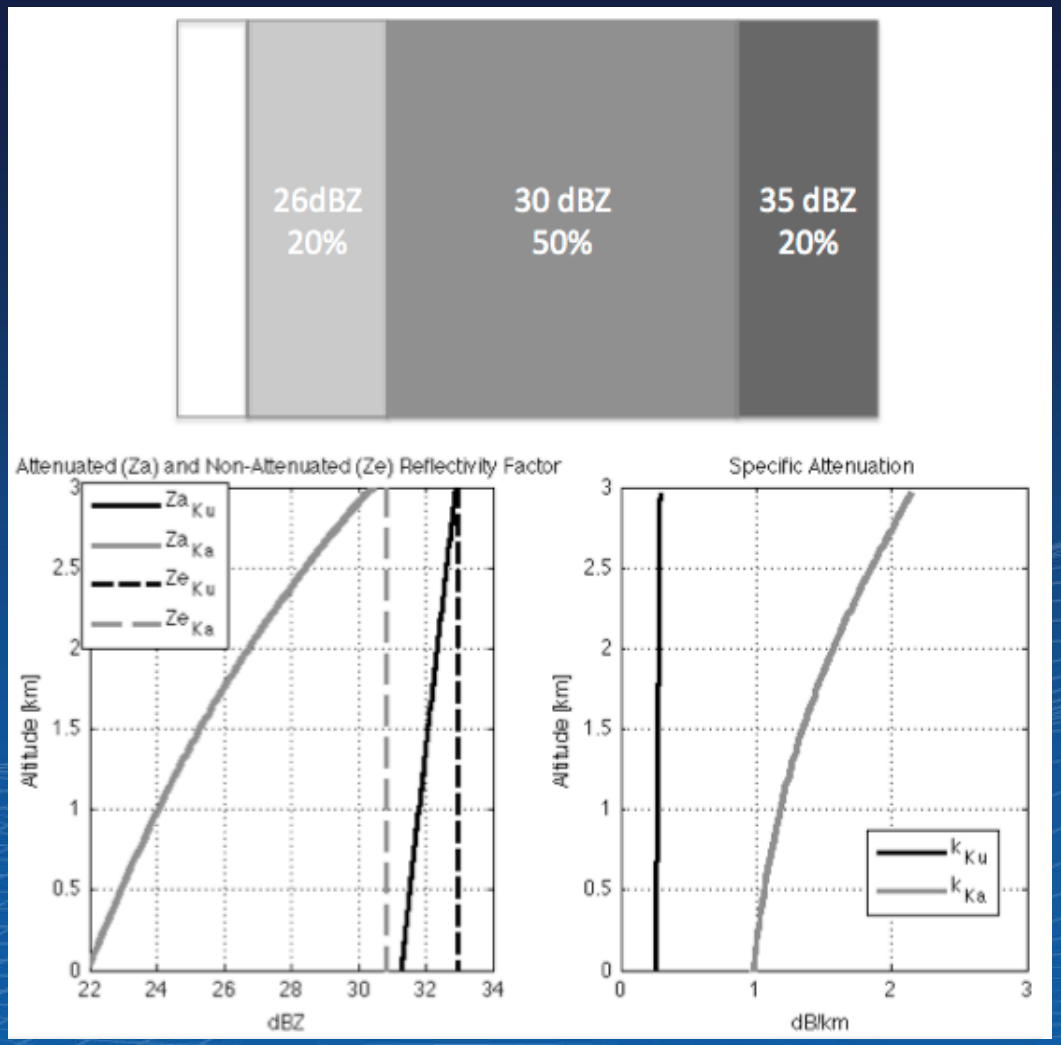
④ Correction and Retrievals

Non-Uniform Beam Filling Impact

The 'column model'

Jet Propulsion Laboratory
California Institute of Technology

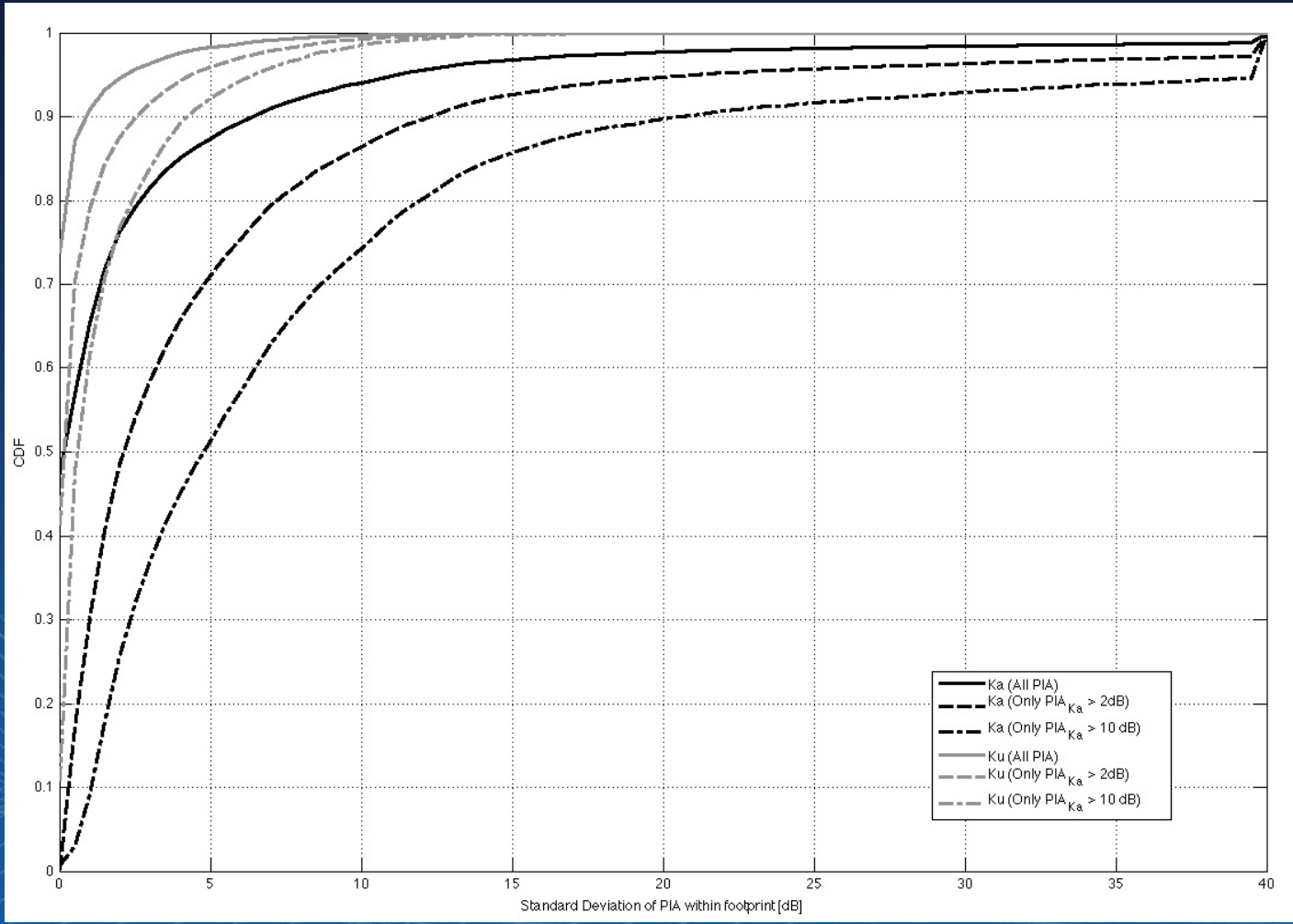
- Non-Uniform Beam Filling = inhomogeneity in the field of reflectivity across the radar beam
- Column Model = the pattern of NUBF is completely correlated along range
- This model was adopted since the first studies (e.g., Nakamura et al. 1991) and is well suited to explain the nature of the problem.
- The higher the specific attenuation the stringer the impact of NUBF➔ higher frequencies are more affected.



Experimental Evidence

Probability of occurrence from the GRIP APR-2 dataset

Jet Propulsion Laboratory
California Institute of Technology



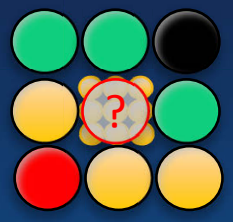
Theoretical Framework

The coefficient of variation

Jet Propulsion Laboratory
California Institute of Technology

- Key parameter describing the degree of NUBF was defined in Iguchi et al. (2000, 2000, 2009).
- In single-frequency systems (TRMM/PR) an estimate of σ_n within the FOV was obtained from the observable σ_n over an 9-neighborhood of FOVs.
- The σ_n is then used to calculate correction factors in the retrieval.
- Alternative approaches for off-nadir beams rely on the range-resolved returns (Meneghini et al. 2012).
- Additional statistical studies provide the means to apply this parameter also to non-column NUBF (Short et al. 2012)

$$\sigma_n = \frac{\sigma_{PIA}}{PIA}$$



$$C'_{SR} = 1 + \frac{\sigma_n^2}{\beta}$$

Our question:

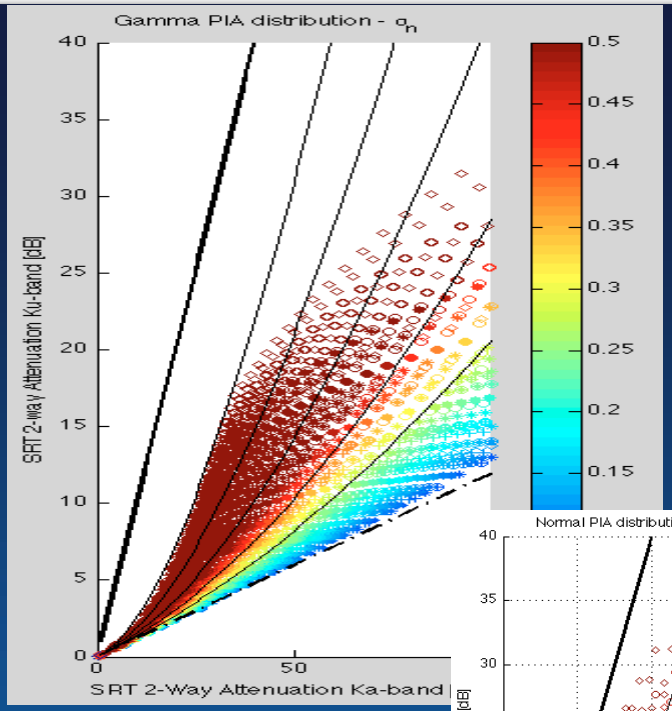
Can co-located multi-frequency measures of NRCS provide a measure of σ_n?

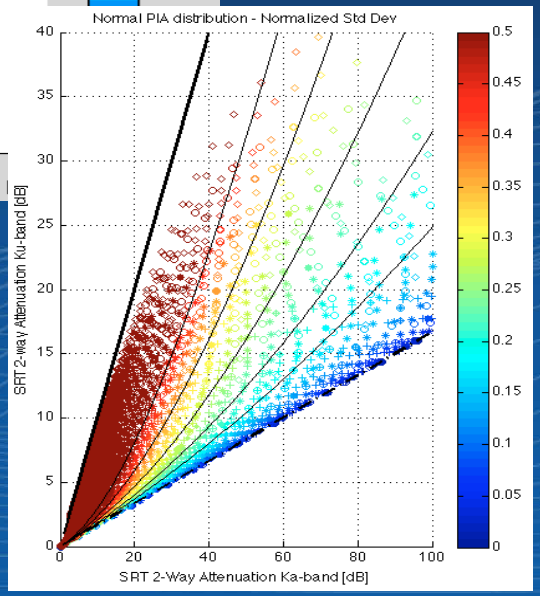
Theoretical Framework

Coefficient of variation vs. multi-frequency PIA

Jet Propulsion Laboratory
California Institute of Technology

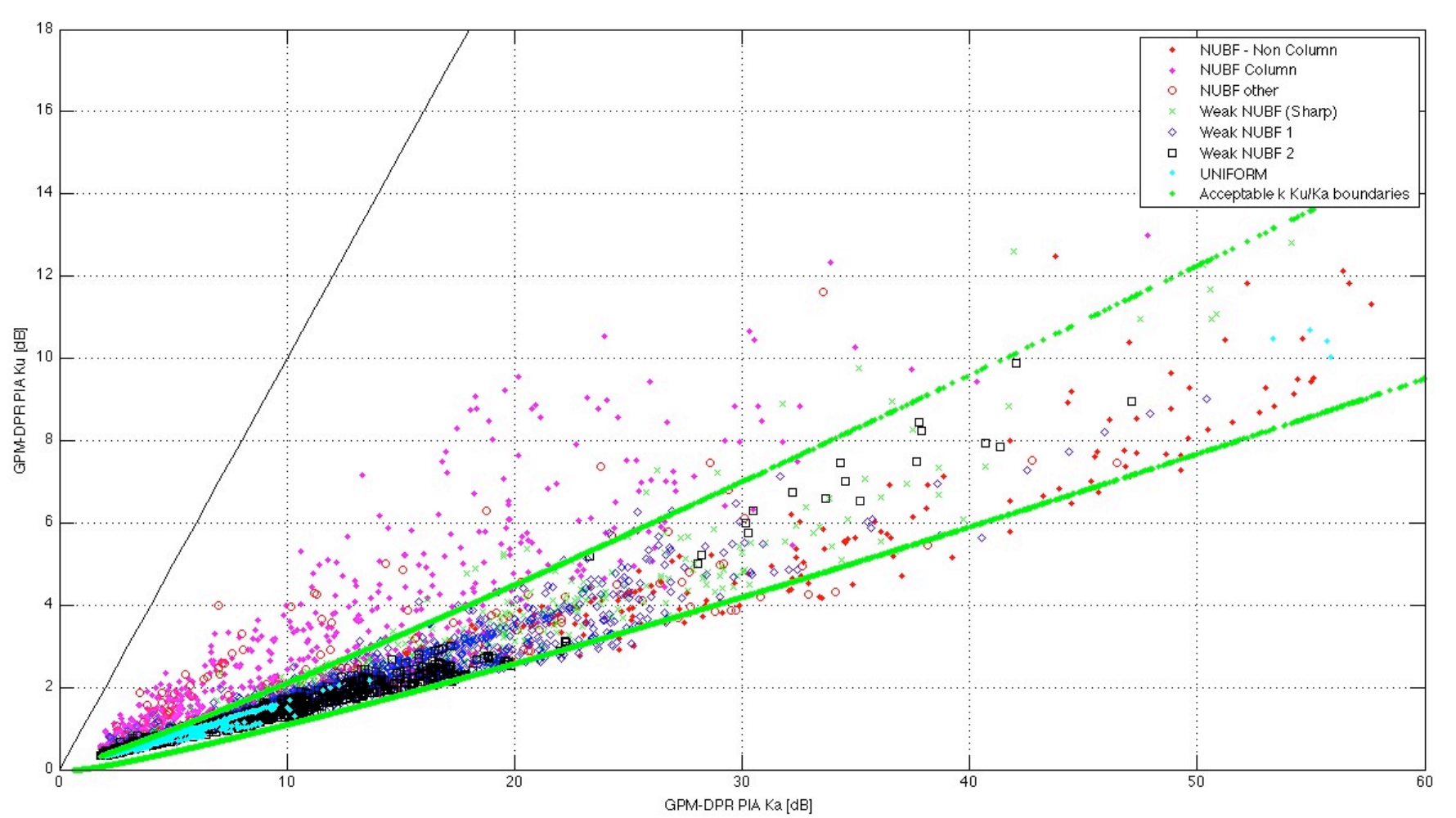
- In the TRMM operational algorithm two shapes have been considered (Iguchi et al. '00, '09):
  - Gamma
  - Log Normal
- The corresponding correction terms have been shown to be comparable.
- They enable elegant analytical solutions.
- How well do these classical monomodal distributions capture the actual distribution of PIA within a 5 km FOV?
- A 'Delta-clear + Gaussian-Rain' simple model is also explored in this paper.





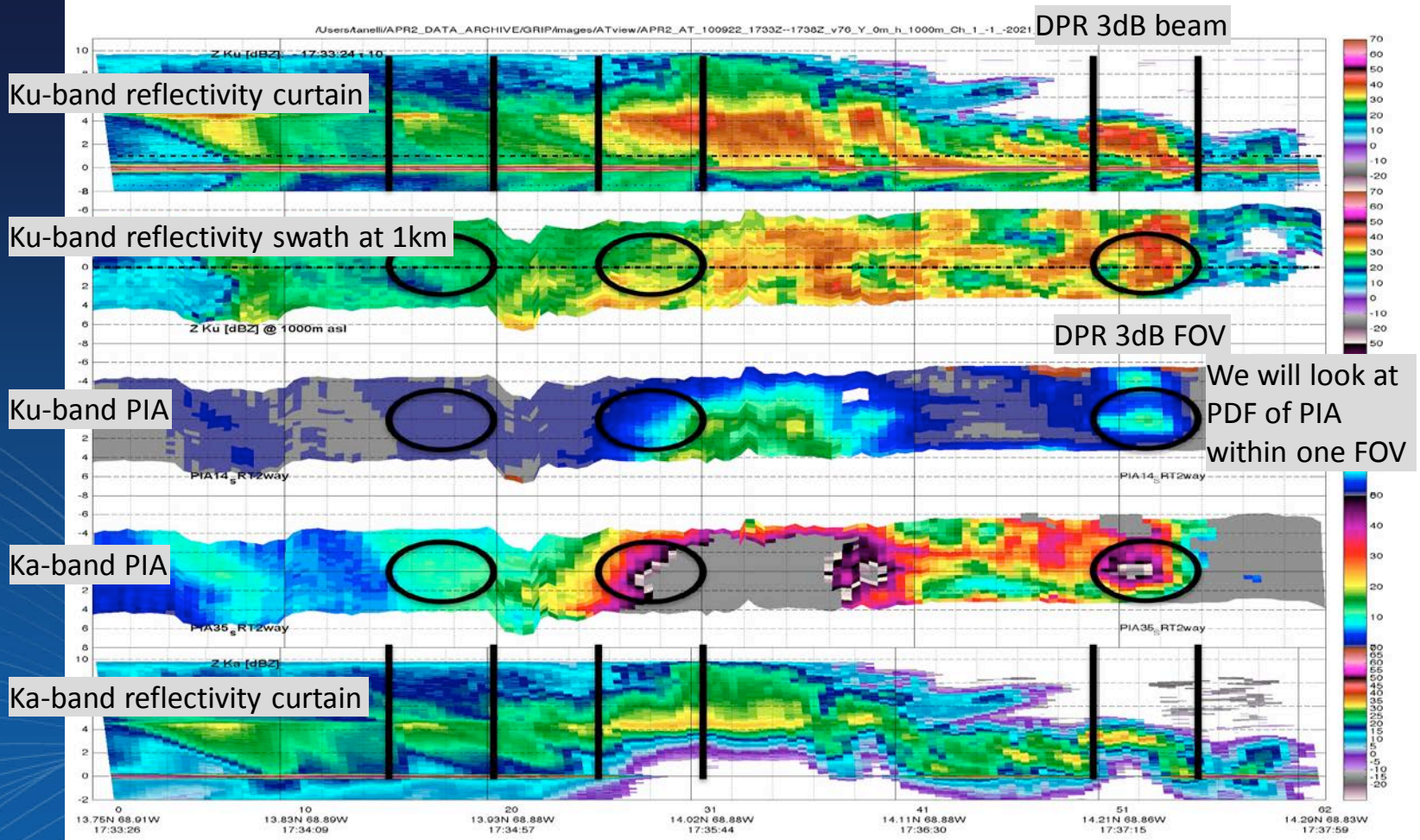
Experimental Evidence

Coefficient of variation vs. multi-frequency PIA



Experimental Evidence

The APR-2 dataset as high-resolution proxy for DPR



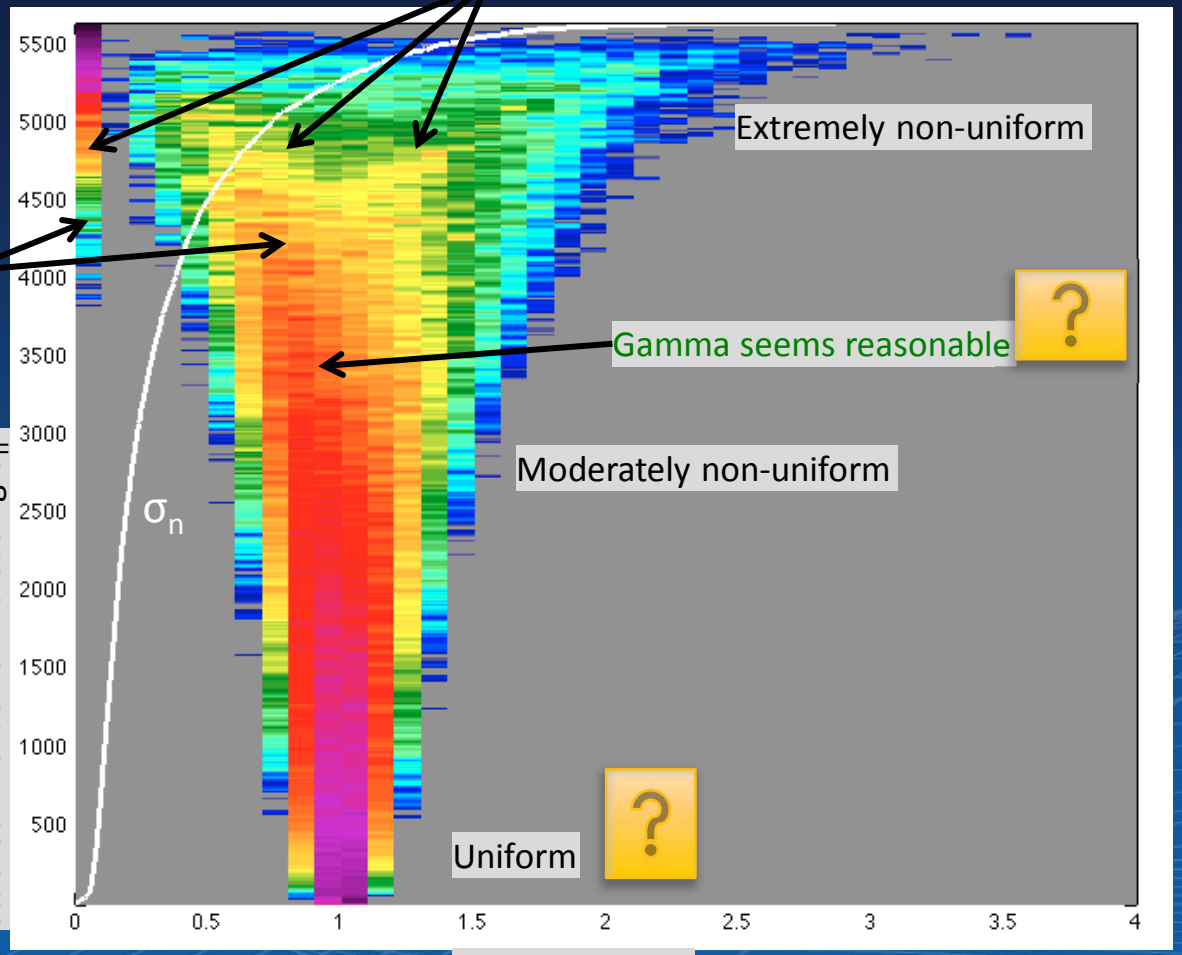
Experimental Evidence

PDF of nomalized PIA within one 5km FOV

Jet Propulsion Laboratory
California Institute of Technology

Only FOV with mean(PIA_{Ka}) > 2dB

Trimodal??



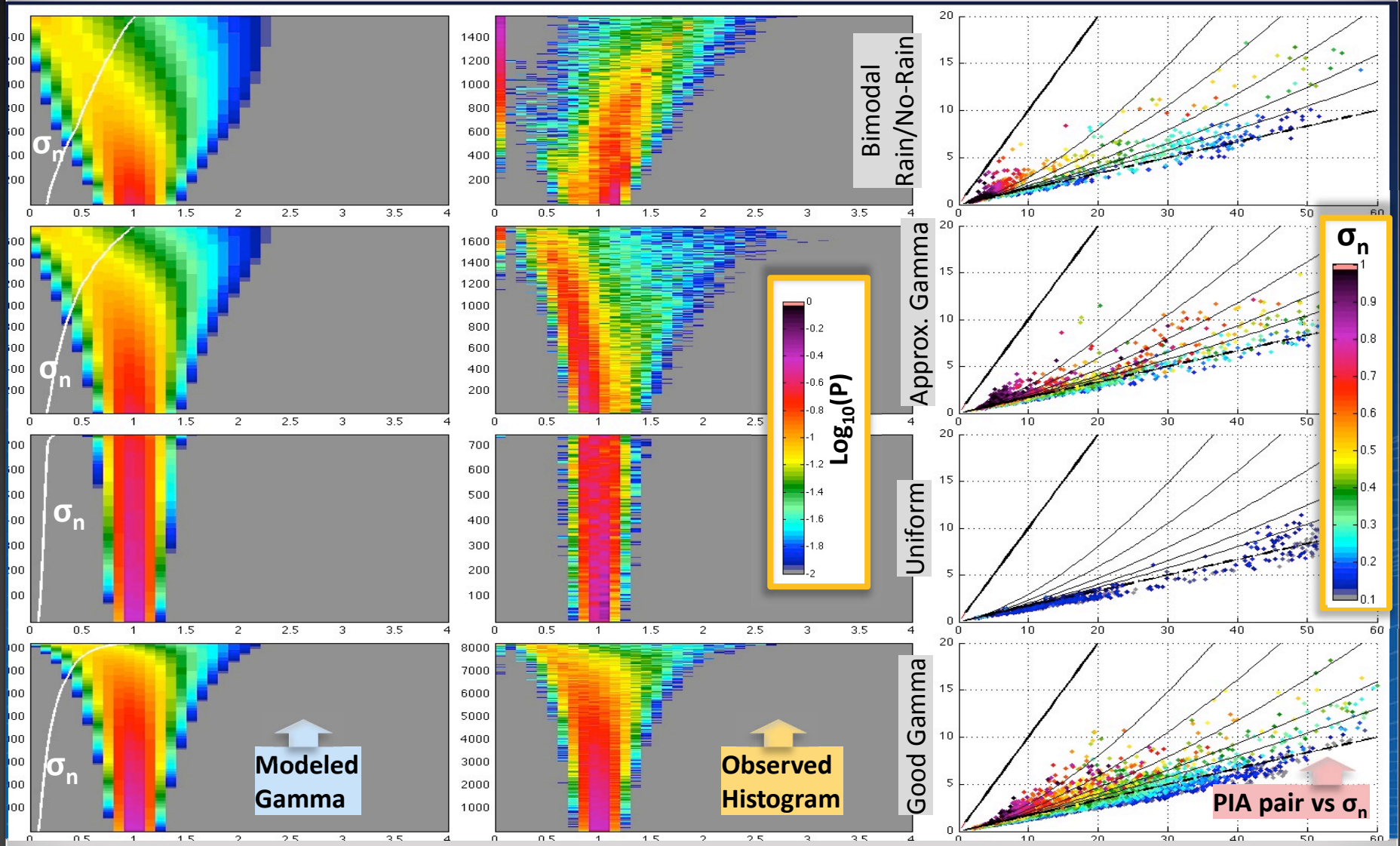
Bimodal with one non-rain mode and one rain mode?

Experimental Evidence

PDF of nomalized PIA within one 5km FOV (2)

Jet Propulsion Laboratory
California Institute of Technology

There is almost never a trimodal distribution, but the no-rain/rain bimodal represents a large fraction of NUBF

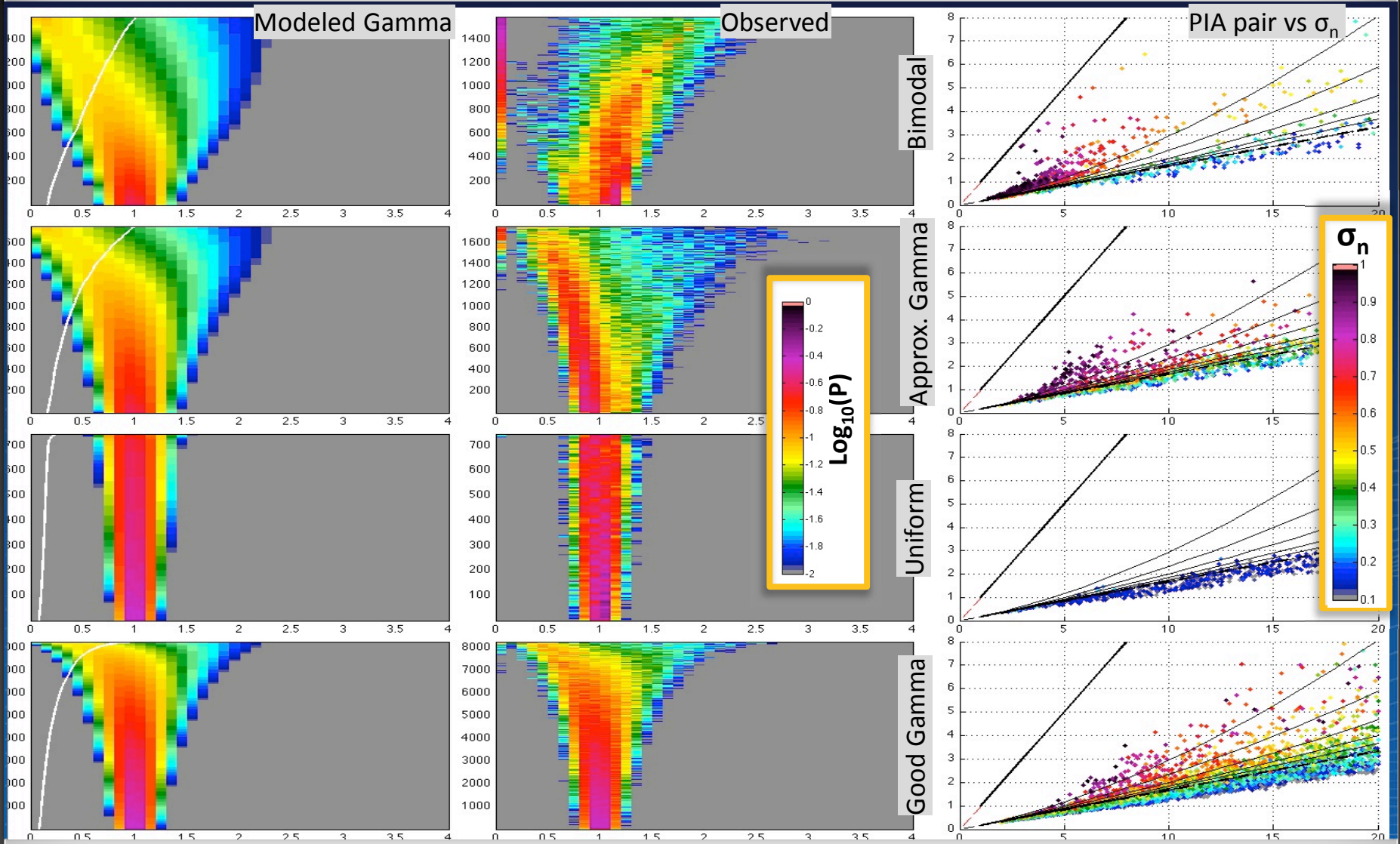


Experimental Evidence

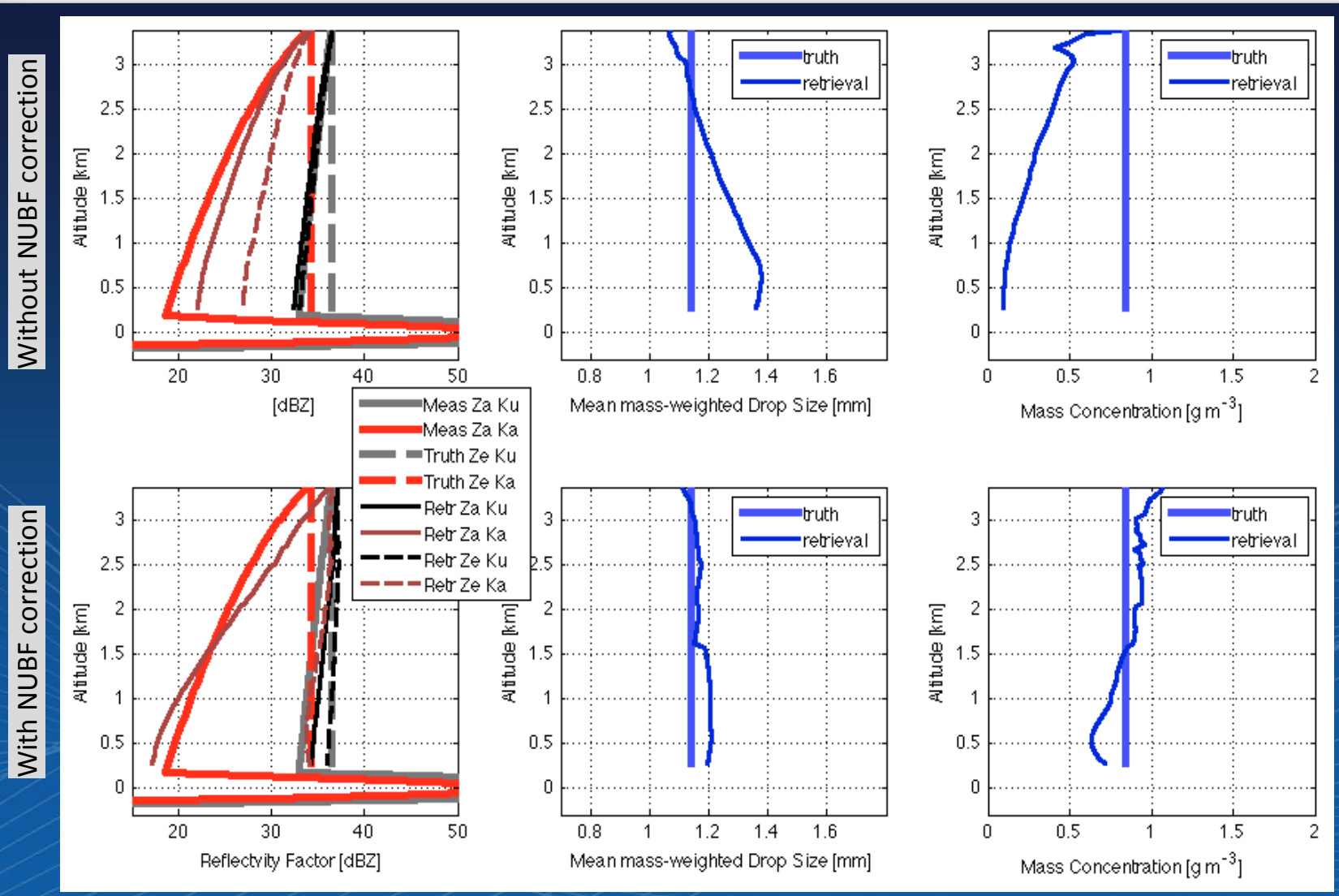
PDF of nomalized PIA within one 5km FOV (2)

Jet Propulsion Laboratory
California Institute of Technology

There is almost never a trimodal distribution, but the no-rain/rain bimodal represents a large fraction of NUBF



Correction and Retrievals

Simulated Column-NUBF profiles & Full Bayesian Retrievals: with and without NUBF correction

Jet Propulsion Laboratory
California Institute of Technology