Uncertainty Analysis of Cloud Properties Retrieved from MICROBASE

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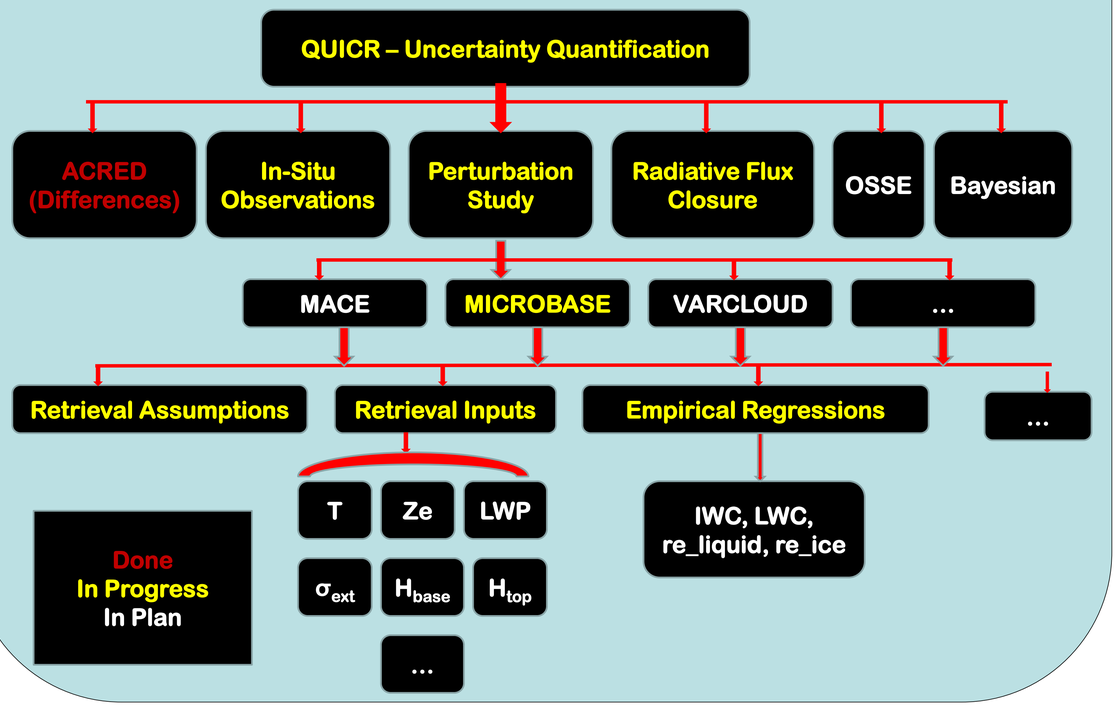
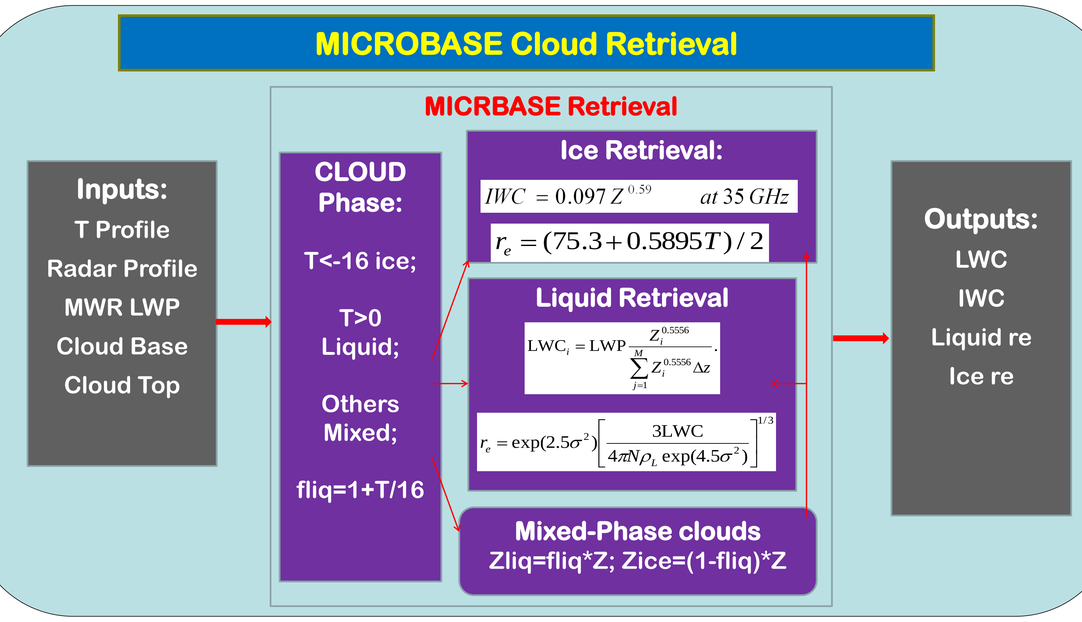
Motivation And Research Plan

The goal of Quantification of Uncertainties in Cloud Retrievals (QUICR) focus group is to develop a methodology for characterizing and quantifying uncertainties in current and future ARM cloud retrievals (VAPs and PI products), separately for different cloud regimes, in support of both retrieval algorithm improvement and cloud modeling study.



MICROBASE Cloud Retrieval



MICROBASE Cloud Retrieval Uncertainties

Uncertainties from errors in the Input Measurements

- LWC: LWP, Ze; - Liquid re: LWP, Ze; - IWC: Ze; - Ice re: Temperature

Uncertainties from the Retrieval Assumptions

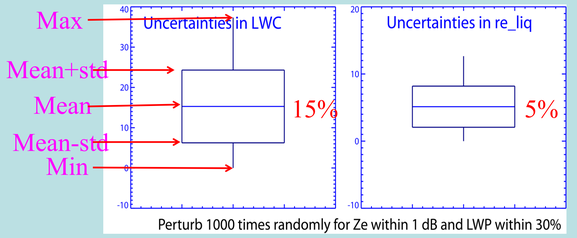
- Liquid re: N assumption; sigma Assumption; - Other Assumptions

Uncertainties from Empirical Regressions

- LWC: LWC ~ Ze; - IWC: IWC ~Ze; - Ice re: re ~T

Uncertainties Associated with the Input Measurements

Properties	Inputs	Input Errors	UQ method	Retrieval Uncertainties
LWC	LWP; Ze	LWP (30%); Ze (1 dB)	Perturbation Method	
Liquid re	LWC	-	$\frac{dlnre}{dlnlwc} = 1/3$	
IWC	Ze	0.5 dB	$\frac{dlnIWC}{dlnZe} = 0.59$	Within 7%
Ice re	T	1 K	$\frac{dre}{dT} = 0.295$	For ice re between 10-38 um, uncertainty is 3%-1%

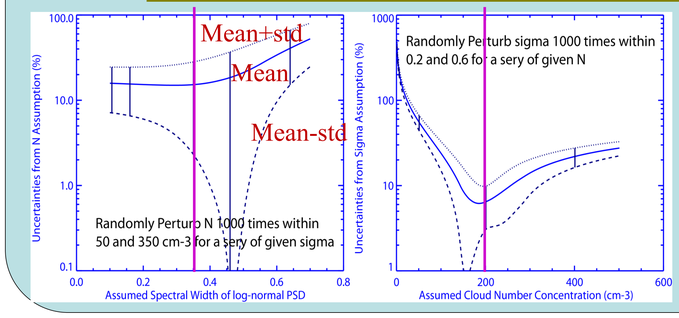


Perturbation method for LWC

Randomly perturb 1000 times to LWP within 30% and Ze within 1dB at the same time without considering the covariance between these two inputs.

Uncertainties (%) Mean (std)	LWC	Re_liq	IWC	Re_ice
From Inputs	15 (10)	5 (3)	Within 7%	1-3%

Uncertainties Associated with the Retrieval Assumptions



Other assumptions have not been considered here, such as PSD, Ice crystal habit, etc.
The random perturbation method has not consider the probability distribution function of N and sigma.

Uncertainties (%) : Mean (std)	Re_liq
From Assumptions in N (sigma=0.35)	15 (15)
From Assumptions in sigma (N=200)	7 (5)
From Assumptions in both N and sigma	??

Uncertainties Associated with the Empirical Regressions

MICROBASE

$$LWC_i = LWP \frac{Z_i^{0.5556}}{\sum_{j=1}^{M} Z_i^{0.5556} \Delta z}.$$

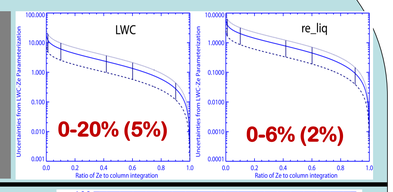
MACE

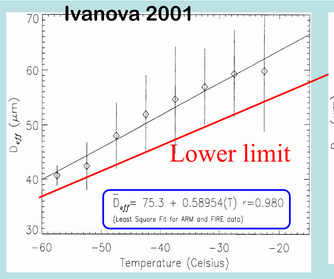
$$LWC_i = LWP \frac{Z_i^{0.5}}{\sum_{j=1}^{M} Z_i^{0.5} \Delta z}.$$

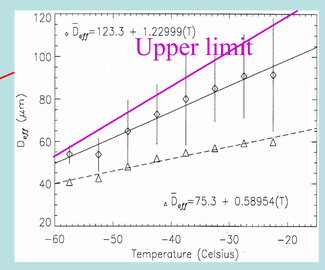
$$LWC_i = LWP \frac{Z_i^{b}}{\sum_{j=1}^{M} Z_i^{b} \Delta z}.$$

Method

For different ratio of radar reflectivity relative to the column integrated value, we randomly perturb parameter b between 0.5 and 0.606.

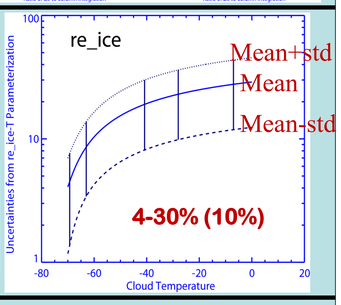


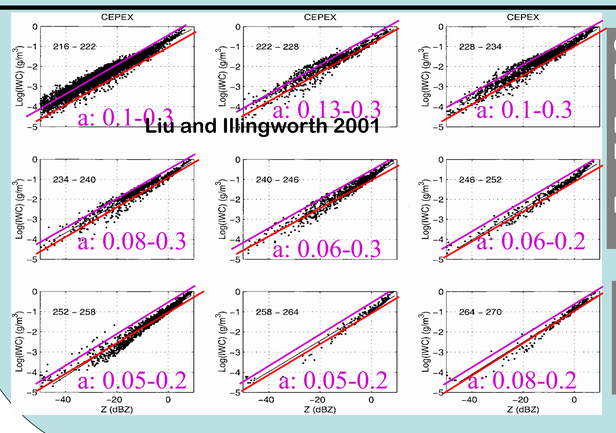




re= (64.4+0.4622T)/2
=15.1+0.2311(T+73.81)
re=(151.5+1.6422T)/2
=15.1+0.8211(T+73.81)

Method: re=a+b(T+c)
Randomly perturb b 1000 times within 0.2311-0.8211 and comparing them to MICROBASE

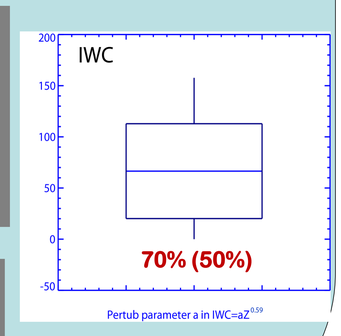




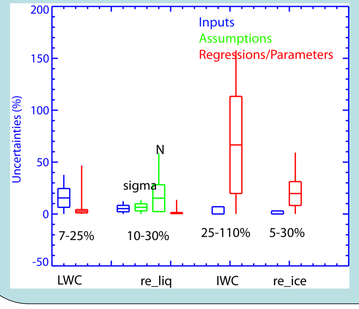
CEPEX: Central Equatorial Pacific Experiment
$IWC=0.0977Z_e^{0.596}$
FIRE: FIRST ISCCP Regional Experiment
$IWC=0.064Z_e^{0.58}$
MICROBASE
$IWC=0.097Z0.59$

Method

For $IWC=aZ_e^{0.59}$; we randomly perturb parameter a 1000 times within 0.05 – 0.25



Conclusions/Discussions



Results

- For LWC, uncertainty related to inputs dominates, 7-25%
- For re_liq, uncertainty related to assumptions (particularly in N) dominates, 10-30%
- For IWC and re_ice, uncertainty related to empirical regressions dominates, which is 20-110% and 5-30%, respectively.

Remaining Issues

- Cloud retrieval uncertainties associated with the phase classification, and for mixed phase clouds have not yet been studied.
- Cloud retrieval uncertainties from other assumptions have not been discussed.
- This study has not considered the possibility distribution of perturbed variables.
- Combination of cloud retrieval uncertainties from different factors require further knowledge (like covariance among them)
- More in-situ aircraft measurements are required for further evaluation and further improvement of empirical regressions.

Ref: Dunn, M., K. L. Johnson and M. P. Jensen (2011), The Microbase value-added product: A baseline retrieval of cloud microphysical properties. DOE/SC-ARM/TR-095.

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