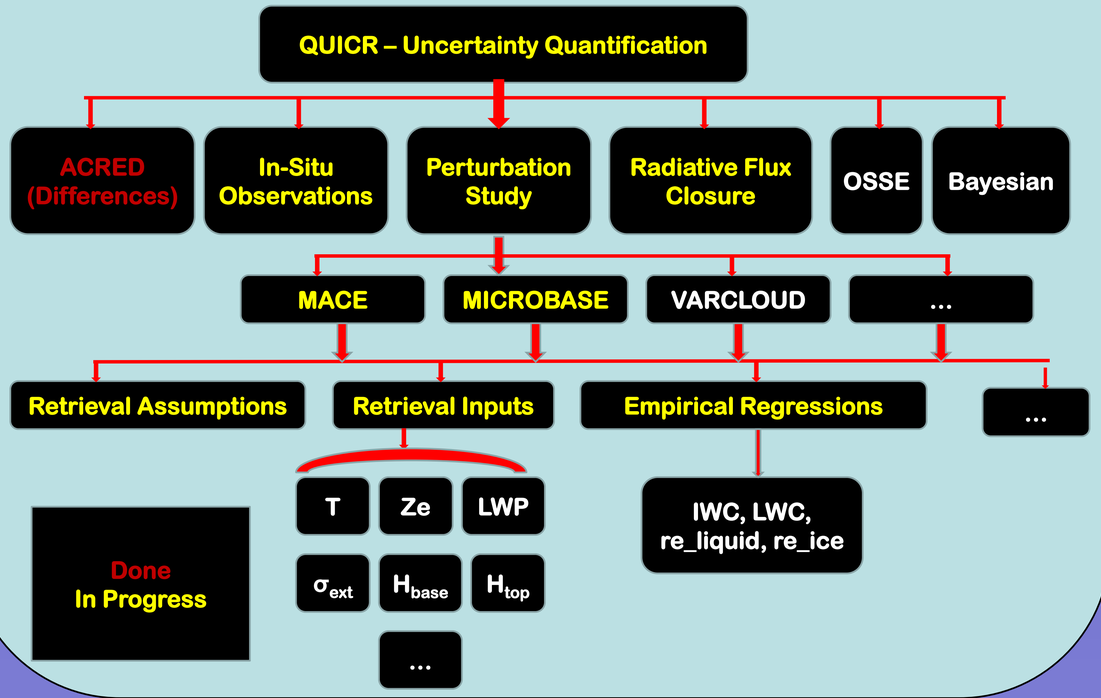
Analysis of Cloud Retrieval Uncertainty in MICROBASE

Chuanfeng Zhao[1](zhao6@llnl.gov), Shaocheng Xie[1], Xiao Chen[1], Maureen Dunn[2], Michael Jensen[2]*

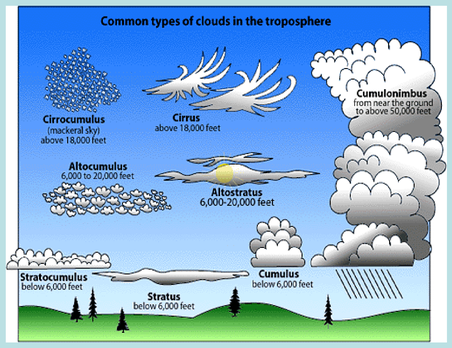
1. Lawrence Livermore National Laboratory, CA, USA
2. Brookhaven National Laboratory, NY, USA

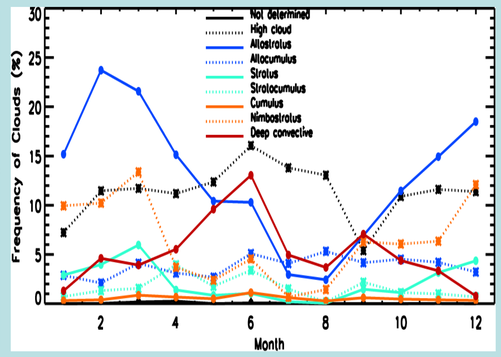
Motivation And Research Plan

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.



Uncertainties in LWC for Nine Types of Clouds at SGP in 1999-2001 (1)





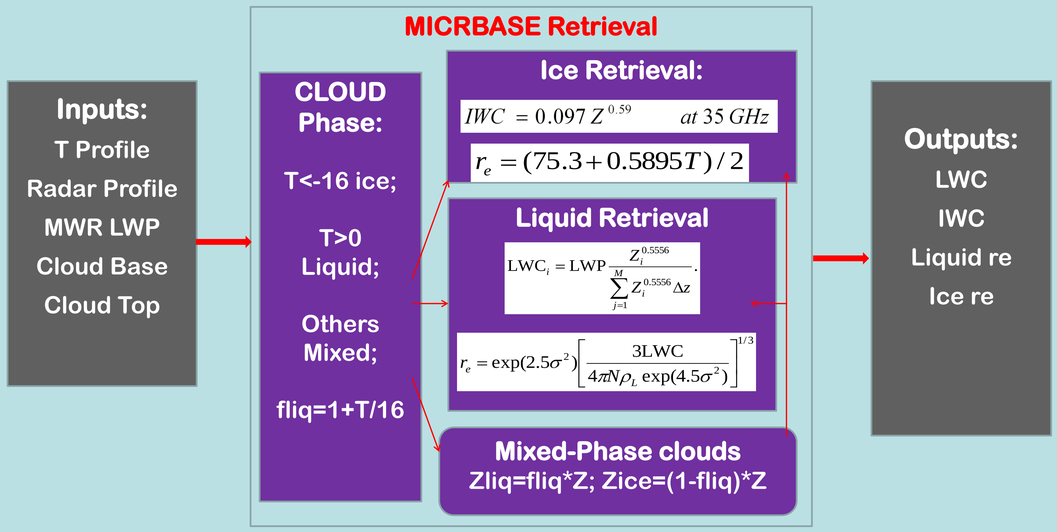
9 Cloud types from ARM Cloud Classification VAP. The cloud classification method (Wang and Sassen 2001) uses ground-based active and passive remote sensors which can provide complementary capabilities to classify cloud phase and cloud type in different climate regions.

Cloud types	Not Determined	High cloud	Altostratus	Altocumulus	Stratus	Stratocumulus	cumulus	nimbostratus	Deep convective	All Types
Ensemble mean (g/m3) (mean/STD)	0.08 / 0.08	0.05 / 0.05	0.06 / 0.03	0.08 / 0.03	0.23 / 0.08	0.10 / 0.06	0.25 / 0.12	0.38 / 0.17	0.61 / 0.26	0.21 / 0.21
Ensemble STD (g/m3) (mean/STD)	0.02 / 0.02	0.01 / 0.01	0.02 / 0.01	0.02 / 0.01	0.06 / 0.02	0.02 / 0.01	0.07 / 0.03	0.11 / 0.05	0.18 / 0.08	0.06 / 0.06
Uncertainties in % (mean/STD)	26 / 4	26 / 4	27 / 1	27 / 1	25 / 1	24 / 1	27 / 1	30 / 1	30 /1	27 / 3

Major ranges of ensemble means and standard deviations (STD) of LWC vary with cloud types. Ensemble mean LWC generally lies between 0.01 and 1 g/m3, with maximum values for deep convective clouds.

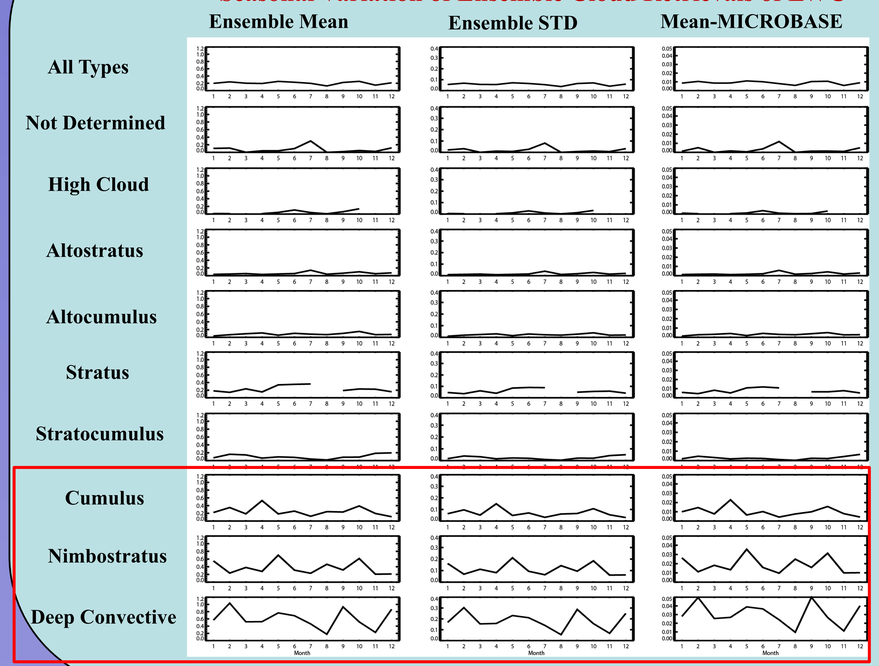
Cloud retrieval uncertainties determined with perturbation method slightly varies with cloud types, with most values between 20% and 30%. The slight variation found here might be related to the same ranges of perturbations among 9 types of clouds, which are generally not true. Largest uncertainties are found for nimbostratus and deep convective clouds.

MICROBASE Cloud Retrieval



Zhao et al. (2012) has indicated the cloud retrieval uncertainties are highly associated with the retrieval inputs, assumptions and parameters in the empirical regression equations. Here we quantify cloud retrieval uncertainties by perturbing these factors within their reasonable ranges.

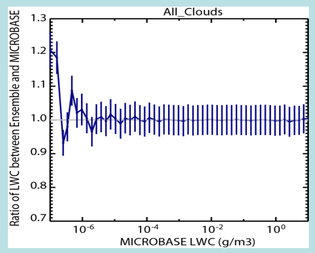
Uncertainties in LWC for Nine Types of Clouds at SGP in 1999-2001 (2)



- Seasonal variation of ensemble standard deviation of LWC follows the change of ensemble mean – the larger the LWC, the larger the uncertainties in absolute values. So does the difference between ensemble mean and default MICROBASE.

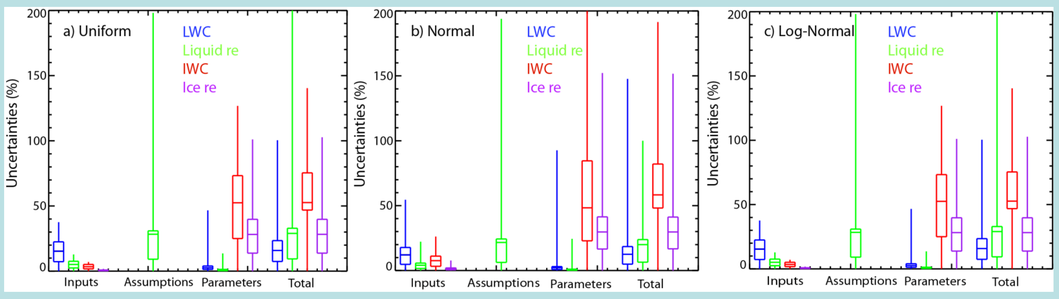
- Different magnitudes and seasonal variations are found for nine types of clouds, with largest values for cumulus, nimbostratus and deep convective clouds.

- For all clouds, ensemble mean-default MICROBASE relative difference in LWC decreases with default LWC.



All Types of Clouds

Uncertainties Associated with Different Factors



- Dominant factor for the cloud retrieval uncertainties varies with the properties retrieved. For LWC and liquid re, the dominant factors are the retrieval inputs (e.g. MWR LWP) and retrieval assumptions, respectively; for ice properties, the dominant factor is the empirical parameterization equations

- The cloud retrieval uncertainties determined from the perturbation method are weakly dependent on the sampling distribution (e.g. uniform, normal and log-normal distributions) used in the perturbations

- Other influential factors (e.g. ice crystal habit) have not been explored in this study

Conclusions

- Cloud retrieval uncertainties can be, at least partially quantified with a perturbation method – Perturbing the cloud retrieval inputs, assumptions, and empirical parameters in the regression equations
- The major uncertainty contributing factor varies with cloud variables that are retrieved; the uncertainties determined with perturbation method are dependent on the sample method of the perturbations, while this dependency is weak in this study
- This study examines the ensemble retrieval results for nine types of clouds, and different LWC major ranges and uncertainties have been found. Generally, the ensemble mean LWC mainly lies between 0.01 and 1 g/m3, with maximum values for deep convective clouds; and the uncertainties varies slightly with cloud types with most values between 20% and 30%.
- The ensemble mean and standard deviations of LWC follows similar seasonal variation, so does the difference between ensemble mean and default MICROBASE. Different magnitudes and seasonal variations have been found for nine types of clouds.
- For all types of clouds, relative difference between ensemble mean and default MICROBASE decrease with default LWC. Differently, ratio of ensemble standard error to default MICROBASE LWC change little with LWC.

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.
Wang, Z. and K. Sassen, 2001: Cloud Type and Macrophysical Property Retrieval Using Multiple Remote Sensors. *J. Appl. Meteorol*, 40, 1665-1682.
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